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ANNUAL REPORT

OF THE

SECRETARY OF WAR

FOR

THE YEAR 1882.

IN FOUR VOLUMES.

VOLUME III.

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REPORT OF THE CHIEF OF ORDNANCE.

WAR DEPARTMENT, ORDNANCE OFFICE,
Washington, October 10, 1882.

SIR: I have the honor to submit the following report of the principal operations of the Ordnance Department during the fiscal year ended June 30, 1882, with such remarks and recommendations as the interests of this branch of the military service seem to require.

The fiscal resources and expenditures of the department during the year were as follows, viz:

Amount in the Treasury to the credit of the appropriations on June 30, 1881	$400,186 11
Amount in the Treasury not reported to the credit of the appropriations on June 30, 1881	2,658 85
Amount in government depositories to the credit of disbursing officers and others on June 30, 1881	175,278 54
Amount of appropriations for the service of the fiscal year ended June 30, 1882	1,762,100 00
Amounts refunded to ordnance appropriations in settling accounts during the fiscal year ended June 30, 1882	2,995 06
Gross amount received during the fiscal year ended June 30, 1882, from sales to officers, from rents, from collections from troops on account of losses of, or damages to, ordnance stores, from Chicago, Rock Island and Pacific Railway Company, from exchange of powder and projectiles, from sales of condemned stores, and from all other sources not before mentioned	390,403 56
Total	2,733,622 12

Amount of expenditures during the fiscal year ended June 30, 1882, including expenses attending sales of condemned stores, exchange of powder, &c	$1,669,276 50
Amount deposited in Treasury during the fiscal year ended June 30, 1882, as proceeds of sales of government property	206,092 97
Amount lapsed into the Treasury from the appropriation "Ordnance material," under act of March 3, 1875, during the fiscal year ended June 30, 1882	16,988 88
Amount turned into the "surplus fund" on June 30, 1882	318 63
Amount in government depositories to the credit of disbursing officers and others on June 30, 1882	216,943 83
Amount transferred from ordnance appropriations in settling accounts during the fiscal year ended June 30, 1882	267 81
Amount in the Treasury not reported to the credit of appropriations on June 30, 1882	7,391 69
Amount in the Treasury to the credit of appropriations on June 30, 1882	616,341 81
Total	2,733,622 12

STATIONS AND DUTIES.

The stations and duties of the officers of the Ordnance Department are as follows: Three at the Ordnance Office; thirty-one at the arsenals, armory, agency, and powder depots; eight on the Ordnance Board and at the foundries; eight at the several military headquarters and ordnance depots; four at the Military Academy; one under the orders of the Secretary of the Interior; one in the Life-Saving Service, under the Secretary of the Treasury; and two on leave of absence, sick. Under the operation of existing laws one officer (Lieutenant Gordon) has been transferred to the department from the line of the Army, after passing a satisfactory examination.

The Ordnance Department provides the armament for our sea-coast defenses, and arms and other ordnance stores for the Army, the militia, the Marine Corps, all other executive departments, to protect public money and property, and the thirty colleges authorized by law to receive them for instruction. It has not only to provide these ordnance and ordnance stores of the very best quality and most perfect workmanship, but to determine on the most effective material for war purposes after long and careful study and trial, and endeavor to keep abreast of the hurrying progress of the age.

Rock Island Arsenal.—The interesting report of the commanding officer is herewith submitted. The work has been prosecuted with most commendable skill and economy.

Benicia Arsenal.—The last appropriation made by Congress for the workshops, will permit their erection at an early day, and place that arsenal in condition to do all the work required of it on the Pacific coast.

San Antonio Arsenal.—The liberal appropriation made by Congress for buildings will provide all the storage room and facilities for repairs, so necessary in an arsenal that supplies that long frontier.

Piccatinny Powder Depot.—The commanding officer makes a detailed report of that reservation, and of the work already performed and to be done, in the establishment of that important depot of gunpowder. It is hoped that Congress will continue to make liberal appropriations for it.

Frankford Arsenal.—The interesting report made by the commanding officer is herewith submitted. This being the only cartridge factory belonging to the government, it should be fostered and sustained by liberal appropriations.

Ordnance Notes.—I have also to submit some very valuable papers on Ordnance and other subjects, prepared by officers of the department. Such papers, published as "Ordnance Notes," have given very general satisfaction. They are distributed freely through the Army, and contain so much of the military literature of the day as to enable those on the frontier and far from books and periodicals to keep well informed of passing events and improvements.

SMALL-ARMS.

There were manufactured at the National Armory, Springfield, Mass., during the last fiscal year ending June 30, 1882, 23,428 arms, viz, rifles, carbines, officers' rifles, and shot-guns. A large amount of work, repairing, making spare parts, &c., was also done.

On June 30, 1882, there were on hand 53,542 arms as a reserve supply.

The Springfield breech-loading arms still continue to give satisfaction to the Army. As a single breech-loader for troops it has no superior, and it is confidently believed that it will hold its place until it is superseded by a magazine gun.

MAGAZINE GUNS.

On my recommendation Congress at its last session provided for the manufacture or purchase of a limited number of magazine guns, should any be recommended by the Board then in session and authorized by the previous Congress. That Board assembled on the 5th of July, 1881, Col. John R. Brooke, Third Infantry, as president, and continued in session until September 30, 1882—a period of fifteen months—when its report was submitted.

Forty guns on thirteen different systems—some being duplicates or modifications of others—were tried by the Board and subjected to certain tests. These forty guns were finally reduced to six, which were put through severe supplementary tests, and the three guns that stood all the tests most successfully and satisfactorily were recommended as "suitable for the military service." The guns, recommended in the order named, are the Lee, the Chaffee-Reece, and the Hotchkiss, and they represent the different systems of the detachable and fixed magazines.

These recommendations of the Board having been approved by the Secretary of War, steps will be taken to provide the guns as soon as the necessary information is obtained upon which to take action.

SPRINGFIELD SHOT-GUNS.

On the suggestion of Col. J. C. Kelton, Assistant Adjutant-General, a shot-gun was prepared at the National Armory, by applying a Springfield breech-loading system to a caliber .58 barrel, reamed out to No. 20 gauge. This was done at little expense, and gave such satisfaction that on the recommendation of the General of the Army two shot-guns with ammunition have been issued to each company in certain designated regiments on the frontier to enable the soldier to hunt for birds and small game. The guns have continued to meet with so much favor that a sufficient number are now being prepared to supply every company west of the Mississippi.

MEDALS—REWARDS FOR TARGET PRACTICE.

General Order No. 53 of May 15, 1882 (substituted for General Order 44, series of 1881), provides that suitably inscribed gold and silver medals be awarded to the successful marksmen in the department, division, and Army contests—to become the absolute property of the winners. These medals are prepared at the Philadelphia mint, and are very creditable in design and finish, and will no doubt give the greatest satisfaction to the recipients and the Army. The last medals ordered are promised in three months, the preparation of the dies being delayed by other more important work. Next year, and thereafter, the medals will be ready before the contests begin, that their delivery to the successful men may be made on the spot.

ARMAMENT OF FORTIFICATIONS.

Herewith are submitted several reports of the "Ordnance Board," on tests and proof of guns and projectiles, made since the date of my last annual report.

In October last an 8-inch breech-loading rifle and an 11-inch breech-loading rifle, converted respectively from a 10-inch and a 15-inch smooth-bore, burst in proof by the rupture of the steel breech receiver made on the Krupp system. The fracture, commencing at the front corners of the slot for the breech block, next the cast iron, passed round the walls of the breech receiver in a plane transverse to the axis. Practically, the steel breech was blown off, leaving the cast-iron body intact. A thorough examination of the metal and fracture leads to the conclusion that the rupture was caused by defective design, aided perhaps by the character of the steel.

An 8-inch breech-loading rifle, with the sharp corners in the breech slot rounded off to prevent the beginning of rupture at those angles, endured 127 rounds, with charges of 50 and 55 pounds, of which 22 rounds were with a violent powder entailing high pressures—a most excellent record. The gun went all to pieces, showing that the parts gave equal support to the system, and proving the excellence of the combination of metals, when of suitable quality, and the design not faulty.

The four 12-inch rifles that were contracted for under act of May 4, 1880, have not been made. The design contemplated guns of cast iron, with wrought-iron tubes and steel breech-receivers, on the Krupp system. These receivers had to be ordered from abroad, but when received and carefully tested, the metal not being up to the standard, they were rejected. Further work on the preparations for making the guns was suspended to await the report of the Getty Board and the action of Congress on the Board's recommendations.

The "Act making appropriations for fortifications and other works of defense, and for the armament thereof, for the fiscal year ending June 30, 1882, and for other purposes," approved March 3, 1881, provides:

> And the President is authorized to select a board, to consist of one engineer officer, two ordnance officers, and two officers of artillery, whose duty it shall be to make examinations of all inventions of heavy ordnance and improvements of heavy ordnance and projectiles that may be presented to them, including guns now being constructed or converted under direction of the Ordnance Bureau; and said board shall make detailed report to the Secretary of War, for transmission to Congress, of such examination, with recommendation as to what inventions are worthy of actual test, and the estimated cost of such test; and the sum of twenty-five thousand dollars, or so much thereof as may be necessary, is hereby appropriated for such purpose.

Under this act a Board, of which General George W. Getty was president, was convened, and after laborious sessions, extending through ten months, made its report to the Secretary of War May 18, 1882. The Board in its report recommended for trial, and for construction and trial, the following guns, viz:

The Lyman-Haskell accelerating or multicharge gun, of 6 inches caliber, for trial.

Dr. W. E. Woodbridge's plan of a wire-wound cast-iron B. L. gun, wire soldered, of 10 inches caliber, for construction and trial.

Plan submitted by the Chief of Ordnance of a cast-iron B. L. gun hooped with steel, of 12 inches caliber, for construction and trial.

Plan submitted by the Chief of Ordnance of a cast-iron B. L. gun, hooped and tubed with steel, of 12 inches caliber, for construction and trial.

Plan submitted by the Chief of Ordnance of a cast-iron M. L. rifled mortar, hooped with steel, of 12 inches caliber, for construction and trial.

W. P. Hunt's plan of a steel B. L. gun, of 10 inches caliber, for construction and trial.

Dr. W. E. Woodbridge's plan of a brazed steel-wire B. L. gun, of 10-inches caliber, for construction and trial.

Plan submitted by the Chief of Ordnance of a steel-wire B. L. gun of 8 inches caliber, for construction and trial.

Dr. W. E. Woodbridge's plan of a steel B. L. gun, longitudinal bars, wire-wound and soldered, of 10-inches caliber, for construction and trial.

A wire-wrapped B. L. steel rifle, after the plan of Schultz, submitted by Col. S. Crispin, of 9 inches caliber, for construction and trial.

This report was transmitted to the Senate by the Secretary of War May 29, 1882, but no action was taken by Congress at its last session to carry out the recommendations of the Board.

These recommendations are now before Congress for its action, and the recent appointment by the Senate of a select committee "to take into consideration the subject of heavy ordnance and projectiles for the armament of the Navy and the sea-coast defenses," and who are to report "to the Senate at its next session," make it proper for the department to await the action of Congress before entering on the manufacture or conversion of heavy cannon.

With the very pressing need for sea-coast armament constantly before us, it should seem expedient to take every advantage of our own resources to help provide for our wants. It will doubtless be practicable for us to produce rifled guns of *moderate power* even from cast iron, provided the cast iron be suitably strengthened with steel hoops, or, better, with hoops on the exterior and a steel tube on the interior. Such guns, however, are very *heavy* in proportion to their power. The substitution of steel wire for the hoops would seem to be an advantageous modification, and its trial, as recommended by the Board, promises important results. A similar plan is now being tried with experimental cast-iron guns in France. For the manufacture of rifled mortars, cast iron strengthened with steel hoops may be used to advantage. In the mortar very great strength is not needed, as the charges employed are small; but since its fire is comparatively uncertain, it is necessary, in order that it may be effective, that what it lacks in accuracy may be made up by the number of mortars used. With such pieces, therefore, cheapness and facility of production are essential requirements, and the small charge and short bore admit of using a comparatively light mortar.

The material out of which *full-power* guns must be made is unquestionably steel. All the first-class powers of Europe have adopted it. Even those that have spent more millions than we have thousands in the effort to determine on the most reliable metal for gun construction, are abandoning cast and wrought iron, either simple or in combination with other metals, and are now devoting their attention to steel, and to steel alone. The marvelous strides in gun construction made within a year or two in the manufacture of guns of great strength and high power, point to the conclusion that encouragement should be given in every way possible to the manufacture of steel in large masses suitable for this purpose. At present tentative efforts have developed but little to encourage the hope that steel guns for coast defense can be produced in this country. The use of wire-wound guns, if they prove as successful as recent experiments here and abroad make us hope, will greatly simplify the problem, by limiting the number and size of the steel masses needed, while the wire itself can now be procured from our own manufacturers. Under the most favorable circumstances, however, the country is in no condition at this time to undertake such constructions wholly out of home products, and the subject is of sufficient importance to arrest the attention and receive the careful consideration of Congress. This subject can only be successfully met either by establishing a national foundry or by assisting and encouraging private foundries to procure the necessary plant and experience.

POWDERS.

Some further experiments have been made during the past year to ascertain the suitableness of our molded powders for heavy guns, employing large charges. With a coarse granulation and high density some very satisfactory results have been obtained.

With the 12.25-inch M. L. rifle, the charge has been augmented to 180 pounds, imparting a velocity of over 1,500 feet to a 700-pound shot without entailing a pressure of more than 29,000 pounds per square inch of bore.

It is probable that the charge may be still further increased without overstraining the gun. With a greater length of bore, such as could be profitably employed with these large charges, there is no doubt but that a considerably higher velocity would be attained. The subject of prismatic powders, of types similar to those employed in European experiments, has also been under consideration, and arrangements have been made to procure trial samples whenever we shall obtain a suitable gun for testing them.

It is believed, however, that our own type of powders possesses a sufficiently wide range of adaptability to enable us to meet very largely, if not to the utmost, the present requirements of heavy guns. It is my intention at least to continue *their development* by further experiments.

PROTECTION OF SUBMARINE MINES.

In February last the Chief of Engineers referred to me a report of the Board of Engineers for Fortifications of February 15, 1882, on the proper means of defending torpedo fields, and recommending volleys from large-bored guns, fired automatically—these guns to be so arranged as to sweep the whole space occupied by the mines and cables. The board suggested that experiments be made to determine suitable kinds of projectiles for the most effective flanking of torpedo lines, and that the attention of this department be invited to the subject. The papers were at once submitted to the Ordnance Board, with the necessary instructions to carry on such experiments as may enable this department to successfully meet this great want in the proper defense of our harbors.

LIGHT ARTILLERY BOARD.

In April, 1881, General Orders No. 39 convened a Board of artillery officers, of which Col. J. C. Tidball was president, "to consider the recent changes in guns, harness, and equipments for light batteries." The action of such a Board I deemed of the first importance, as little had been done in that direction for some years.

The Board made a preliminary report to enable this department to manufacture samples of carriages, harness, &c., embodying its views, so as to present to a subsequent Board the articles or improvements recommended, that action might be taken on practical results. The preparation of a metal field carriage, limber, and caisson has been greatly delayed by the difficulty of procuring suitable material in proper shapes, but it is confidently believed that we will be ready for the action of an artillery board at an early day.

The large amount of artillery and its supplies left from the war, and the small appropriations available for such purposes, has deterred the department from entering until now upon the increased expenditures attendant on the introduction of new material. The adoption of steel breech-loading field guns in all the armies of Europe calls for experimental action on our part, and I have now in course of preparation a design for a steel B. L. gun suited to the wants of our service, and have directed inquiries to be made into the possibility of making such a gun in this country from the products of our own foundries and workshops. It is believed that, with proper encouragement, field guns can be made here without the necessity of going abroad for the steel.

U. S. TESTING MACHINE.

The report, by the commanding officer of the Watertown Arsenal, of tests of iron and steel, and other materials for industrial purposes, made during the last fiscal year, has been received, and will be submitted for transmission to Congress at the opening of the next session, as provided by law. In the last Army appropriation bill it is provided:

> And the Chief of Ordnance shall give attention to such programme of tests as may be submitted by the American Society of Civil Engineers, and the record of such tests shall be furnished said society, to be by them published at their own expense.

I recommended the passage of this provision, believing it to be for the best interests of the public that those who are so largely interested in prominent and important constructions could best advise the department as to the tests most needed for present and future use. I was anxious that authority be given by Congress to publish monthly bulletins of tests made, that the engineer and the manufacturer might have the earliest possible information.

The results given by the testing machine are for the benefit of the whole country, and the people should be permitted to utilize the results as fast as they are obtained. This can only be effected by their immediate publication, and I respectfully recommend that this be authorized.

The capacity of the machine is limited to tests of extension and compression. I have been advised by distinguished civil engineers and by the commanding officer Watertown Arsenal that either additions to the present machine or additional machines should be provided for the tests of torsional and transverse resistance. The latter is believed to be the better plan, and two other machines ought to be built. I have, therefore, submitted estimates of $100,000 for the purpose.

MILITIA.

To more completely arm and equip the whole body of the militia, as contemplated by the act of 1808 making an annual appropriation of $200,000, that amount should be largely increased. The bill (S. 1596) reported from the Senate Committee on Military Affairs, and now on the calendar, provides for a substantial increase to this appropriation, and contains other important provisions which would result in the greatest benefit to the militia. I strongly recommend its passage. It is as follows:

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That section sixteen hundred and sixty-one of the Revised Statutes be, and the same is hereby, amended and re-enacted so as to read as follows:

SECTION 1. That the sum of six hundred thousand dollars is hereby annually appropriated, to be paid out of any money in the Treasury not otherwise appropriated, for the purpose of providing arms, equipments, ammunition, ordnance stores, and tents for the militia.

SEC. 2. That said appropriation shall be apportioned among the several States and Territories on the books of the Ordnance Department by the Chief of Ordnance of the Army, under the direction of the Secretary of War, according to the number of Representatives or Delegates to which each State and Territory respectively is entitled in the Congress of the United States: *Provided, however*, That each State and Territory shall only be entitled to the benefits of so much of the appropriation apportioned to it as the proportion of the number of its regularly enlisted, organized, and uniformed active militia, as determined by the report of the Secretary of War made on the preceding first Monday in February, bears to the maximum number of active militia for which such State or Territory is entitled to the benefits of this act. And the amount of said appropriation which is thus determined not to be available shall be covered back into the Treasury.

SEC. 3. That in time of peace the number of active militia for which each State and Territory shall be entitled to receive its apportionment of the appropriations made by this act shall not exceed six hundred regularly uniformed-commissioned officers and enlisted men for each Representative and Delegate to which such State or Territory is entitled in the Congress of the United States.

SEC. 4. That the purchase or manufacture of ordnance, ordnance stores, and tents for the militia under the provisions of this act shall be made by the Chief of Ordnance of the Army, under the direction of the Secretary of War, and they shall be receipted for and shall remain the property of the United States, and be annually accounted for to the Chief of Ordnance of the Army by the governors of the States and Territories, for which purpose the Chief of Ordnance of the Army, under the direction of the Secretary of War, shall prescribe and supply the necessary blanks, and make such regulations as he may deem necessary to protect the interest of the United States.

SEC. 5. That all arms, equipments, ordnance stores, or tents which may become unserviceable or unsuitable shall be examined by a board of officers of the militia, and its report shall be forwarded by the governor of the State or Territory direct to the Chief of Ordnance of the Army for the action of the Secretary of War, who shall direct what disposition, by sale or otherwise, shall be made of them; and the proceeds of such sale shall be covered into the Treasury of the United States.

SEC. 6. That for all the purposes of this act the District of Columbia shall be accounted and treated as a Territory entitled to one Delegate in Congress.

The following quotations are from the committee's report, which accompanies the bill:

That in addition to the resolution instructing us to consider the propriety of increasing the annual appropriation for the militia, there have been referred to us a large number of petitions from the officers of the militia relative to an increase of the appropriation and other amendments to the existing militia law.

And again:

A simple statement of fact appears to be a sufficient response to the resolution of the Senate. That an appropriation fixed in 1808 to provide for seventeen States, with a population of eight millions, is inadequate to provide for thirty-eight States with a population of fifty millions needs no argument. The Chief of Ordnance has for many years urged Congress to increase the appropriation; it was considered and favorably reported to the Senate by this Committee in the Forty-fifth Congress, and we think it would be difficult to conceive any reasonable argument against it. * * *

It will be perceived that no provision is made as to the mode of apportioning the appropriation between the States, no requirements for accountability for the property furnished, or limitation on the disposition that the States may make of it. The greatest defect of the law, however, is that it does not allow the furnishing of tents and other articles necessary to provide for camps of instruction. To this omission of the law is largely due the disparity between the different States in the strength and efficiency of the militia.

* * * We accordingly report herewith a bill to increase the annual appropriation to $600,000, and making provisions for its apportionment, and for the care, accountability, and disposition of property issued under it. We also provide in the bill that each State shall only receive such proportion of the amount apportioned to it as the actual number of its active militia bears to a fixed maximum, and we believe this provision wisely calculated to foster and encourage the formation of volunteer organizations in those States where but few now exist.

There have been no material changes in the law relative to the organization of the militia since its original enactment in 1792, and it is obvious that many of its provisions are now obsolete and many amendments desirable.

Our standing army is a small one. For the defense of the country our main dependence is on our militia. The militia should, therefore, be kept in the best condition possible for actual service. Volunteer organizations in every State and Territory should be encouraged, and every effort made to promote their efficiency in drill and discipline, and make them skillful in the use of their arms. It is the best way, and the only way, to render them a sure and safe reliance on the breaking out of war, and before a little campaigning has inured them to hard service and disciplined them into old soldiers.

It is earnestly recommended that the special attention of Congress be invited to this subject, in order that the bill above quoted may receive favorable consideration at the ensuing session.

I have the honor to submit the following papers, heretofore referred to:

Appendix 1.—Statement of principal articles procured by fabrication at the arsenals during the year ended June 30, 1882.

Appendix 2.—Statement of principal articles procured by purchase at the arsenals during the year ended June 30, 1882.

Appendix 3.—Statement of ordnance, ordnance stores, &c., issued to the military establishment, exclusive of the militia, during the year ended June 30, 1882.

Appendix 4.—Apportionment for the fiscal year ended June 30, 1882, of the annual appropriation of $200,000 for arming and equipping the militia, under sections 1661 and 1667 Revised Statutes.

Appendix 5.—Statement of ordnance, ordnance stores, &c., distributed to the militia from July 1, 1881, to June 30, 1882, under section 1667 Revised Statutes.

Appendix 6.—Statement of arms, ammunition, &c., distributed to the Territories and States bordering thereon from July 1, 1881, to June 30, 1882, under the joint resolutions of July 3, 1876, March 3, 1877, and June 7, 1878, and the act of May 16, 1878.

Appendix 7.—Statement of ordnance, ordnance stores, &c., distributed to colleges from July 1, 1881, to June 30, 1882, under section 1225 Revised Statutes.

Appendix 8.—Statement of arms and ammunition issued to the executive departments during the year ended June 30, 1882, under the provisions of the act of March 3, 1879.

Appendix 9.—Report of action taken during the year ended June 30, 1882, under the provisions of the act approved March 3, 1881.

Appendix 10.—Report of the principal operations at the Rock Island Arsenal, Illinois, during the fiscal year ended June 30, 1882, Lieut. Col. D. W. Flagler, Ordnance Department, commanding.

Appendix 11.—Report of the principal operations at the Benicia Arsenal, California, during the fiscal year ended June 30, 1882, Col. J. McAllister, Ordnance Department, commanding.

Appendix 12.—Report of the principal operations at the Piccatinny powder depot, New Jersey, during the fiscal year ended June 30, 1882, Maj. F. H. Parker, Ordnance Department, commanding.

Appendix 13.—Report of the principal operations at the Frankford Arsenal, Pennsylvania, during the fiscal year ended June 30, 1882, Maj. S. C. Lyford, Ordnance Department, commanding.

Appendix 14.—Report for the year ended June 30, 1882, by Capt. F. Heath, Ordnance Department, commanding the Cheyenne Depot.

Appendix 15.—Report for the year ended June 30, 1882, by Capt. S. E. Blunt, chief ordnance officer, Military Department of Dakota.

Appendix 16.—Proof report, &c., of 8-inch breech-loading rifle No. 5.

Appendix 17.—Report of the Board on Heavy Ordnance and Projectiles, under act approved March 3, 1881.

Appendix 18.—Progress report on experimental cannon powders, by Capt. Charles S. Smith, Ordnance Department.

Appendix 19.—Report on European ordnance and manufactures, by Col. S. Crispin, Ordnance Department.

Appendix 20.—Reports on the inspection of projectiles, by Lieut. Henry Borup, Ordnance Department.

Appendix 21.—Present method of target practice at the Frankford Arsenal, by Lieut. M. W. Lyon, Ordnance Department.

Appendix 22.—The manufacture of russet leather, and its adaptability for the military service, by Capt. D. A. Lyle, Ordnance Department.

Appendix 23.—Vent-punch and gimlet for the Life-Saving Service, by Capt. D. A. Lyle, Ordnance Department.

Appendix 24.—Assembling, and wearing infantry equipments, by Capt. A. L. Varney, Ordnance Department.

Appendix 25.—Cartridges and friction primers for the military service, by Lieut. Col. J. M. Whittemore, Ordnance Department.

Appendix 26.—Mechanical motion, by Lieut. Col. A. R. Buffington, Ordnance Department.

Appendix 27.—Metrical into United States measures, and *vice versa*, by Lieut. Rogers Birnie, Ordnance Department.

Appendix 28.—Determination of the accuracy of small-arm firing, by Capt. O. E. Michaelis, Ordnance Department.

Appendix 29.—Report on Cranston's safety lighting attachment, by Capt. D. A. Lyle, Ordnance Department.

Appendix 30.—Report of the Board on Magazine Guns.

Appendix 31.—Deviations of small-arm projectiles, by Capt. John E. Greer, Ordnance Department.

Appendix 32.—Showing the stations and duties of the officers of the Ordnance Department.

Appendix 33.—Proof of 11-inch breech-loading chambered rifle No. 1, by Capt. Charles S. Smith, Ordnance Department.

REPORTS OF THE ORDNANCE BOARD.

Appendix 34.—Report on the 11-inch breech-loading chambered rifle No. 1.

Appendix 35.—Report on the steel parts of 11-inch breech-loading chambered rifle No. 1.

Appendix 36.—Report on the 8-inch breech-loading chambered rifle No. 2.

Appendix 37.—Report on the steel for 12-inch breech-loading guns and mortar howitzer.

Appendix 38.—Report on the comparative trials of the Butler and Arrick projectiles.

Appendix 39.—Report on protection of magazines from lightning.

I have the honor to be, very respectfully, your obedient servant,

S. V. BENÉT,
Brigadier-General, Chief of Ordnance.

To the Hon. SECRETARY OF WAR.

APPENDIX 1.

Statement of principal articles procured by fabrication at the arsenals during the fiscal year ended June 30, 1882.

CLASS II.

15 carriages for Gatling guns.

CLASS III.

6 breech sights for Hotchkiss mountain gun.
24 breech sights for 8-inch rifles.
2 breech sights for 8-inch siege howitzer.
6 breech sights for 30-pounder Parrott gun.
1 brass breech sight.
1 gun sight and elevating device, Zalinski's.
2 leather watering buckets.
16 galvanized iron watering buckets.
4 fuse blocks.
50 gunners' gimlets.
1 gunner's pouch for breech sight.
62 handspikes, maneuvering.
28 handspikes, trail, for Gatling gun.
1 set harness for Gatling cart (2 horses).
10 sets harness for Hotchkiss mountain gun.
10 sets harness for Laidley cavalry forge.
10 ladles and staves for 8-inch rifles.
31 lanyards for friction primers.
2 front sights for 8-inch rifle howitzer.
4 front sights for 8-inch rifle.
5 front sights for 12-pounder mountain howitzer.
4 front sights for 3-inch rifle gun.
47 pass boxes for 8-inch rifle.
2 pouches for 8-inch rifle howitzer sights.
1 pouch for pendulum hausse.
2 priming wires for field guns.
50 priming wires for 8-inch rifle.
2 quoins for 8-inch siege howitzer.
1 quoin for siege carriage.
1 rammer and stave for 8-inch siege howitzer.
66 rammers and staves for 8-inch muzzle-loading rifle.
20 pairs shell hooks for 8-inch rifle.
1 scraper for cannon.
4 sponge covers for 10-pounder Parrott or 3-inch rifled gun.
66 sponge covers for 8-inch rifle.
2 sponges and rammers for 12-pounder mountain howitzer.
6 sponges and rammers for 3-inch wrought iron or steel gun.
65 sponges and staves for 8-inch rifle.
2 sponges and staves for 10-inch rifle.
1 sponge and stave for 8-inch siege howitzer.

50	thumb-stalls.
10	tompions for 3-inch rifled guns.
9	tompions for 12-pounder mountain howitzer.
4	tompions for siege gun, 4.5 inch.
50	tube pouches or boxes.
121	vent covers.
50	vent punches for 8-inch rifle.
33	vent pieces.
50	water tubs.
20	worms and staves for 8-inch rifle and 100-pounder Parrott.
1	interpolator, Paddock's.
46	muzzle covers and straps.
20	rammer props for 8-inch rifle.
1	cover for Hotchkiss revolving gun.

CLASS V.

15	wire canisters, filled, for 8-inch rifle.
4	wire canisters, filled, for 10-inch rifle.
3,998	shell and cases for 1.5-inch Hotchkiss revolving cannon, filled and fixed.
5,000	shells and cases for 1.65-inch Hotchkiss mountain guns, filled and fixed.

CLASS VI.

23,036	Springfield rifles, caliber .45.
276	Springfield shot guns.
11	marksmen's rifles.
50	officers' rifles, caliber .45.
52	Springfield rifles, caliber .45, for infantry and cavalry.
50	cadet swords.

CLASS VII.

CAVALRY ACCOUTERMENTS.

2,500	carbine slings, grained or waxed leather, black.
3,500	pistol-belt holsters, Schofield's Smith & Wesson pistols.
75	saber belts and slings, O. M. No. 18.

INFANTRY EQUIPMENTS.

15,193	bayonet scabbard bodies, steel.
13,930	bayonet scabbards, steel, Hoffman's attachment.
1,000	blanket bags and straps.
13,169	cartridge boxes, pattern 1874.
1,600	cartridge boxes, pattern 1874, caliber .50.
52	knapsacks and straps, wood frames.
10,000	haversack straps.
8,050	canteen straps.
5,227	blanket bags and straps, with shoulder straps.
7,986	canteens.
3,200	canteens and straps.
6,002	cartridge-belt plates.
10,040	gun slings.
5,000	haversacks.

8	sliding frogs for bayonet scabbards.
373	sliding frogs for non-commissioned officers' swords.
3,600	haversacks and straps.
9,068	meat cans.
11,967	tin cups.
1,022	waist belts, grained leather.
2,639	waist belts and plates, pattern 1874.
1	waist belt, non-commissioned officer's.
20	waist belts and plates, cadet.

APPENDAGES.

33,209	headless shell extractors.
8,668	jointed ramrods.
33,398	screw-drivers.
1,930	wooden wiping rods.
450	brush wipers for shell.
1	wiper.

HORSE EQUIPMENTS.

2,000	girths, hair or cinchas.
2,500	halters and straps.
4,982	horse brushes, leather backs.
12	carbine holsters and straps.
10,400	lariats.
4,450	picket pins.
4,000	nose bags.
1	saddle, Whitman.
2,500	saddles, leather covered.
501	saddle bags, canvas.
3,065	side lines.
1,900	saddle bags, leather.

CLASS VIII.

1,290	blank cartridges, 1 pound.
5,400	blank cartridges, ½ pound.
500	blank cartridges, 2 pound.
12,472	blank cartridges, 3-inch gun.
5,000	blank cartridges, 12-pounder.
11,037	blank cartridges, 6-pounder, field gun.
20,117	blank cartridges, 12-pounder, field gun.
2,662,581	rifle-ball cartridges, caliber .45.
758,929	carbine-ball cartridges, caliber .45.
538,963	rifle and carbine blank cartridges, caliber .45.
85,910	rifle and carbine blank cartridges, caliber .50.
1,020	cartridges for shot guns.
532,068	rifle-ball cartridges, caliber .45, model 1881, 500-grain bullets.
22,620	blank cartridges for machine guns.
10,030	rifle-ball cartridges, caliber .50.
600	rifle-ball cartridges, caliber .45, experimental.
105,230	revolver blank cartridges, caliber .45.
400,000	rifle bullets, lubricated, caliber .50.
2,894,950	rifle bullets, lubricated, caliber .45.
869,000	rifle bullets, lubricated, caliber .45, flat point.
31,520	rifle bullets, lubricated, caliber .45, model 1881 (500 grains).

1,000,000	round balls, lubricated, caliber .45.
295,150	friction primers.
2,120	electric primers.
155$\frac{9}{16}$	pounds composition for friction primers.
216¼	pounds priming composition for cartridges.

CLASS IX.

140	blocks.
15	blocks, half.
30	blocks, quarter.
2	blocks, iron, single.
2	blocks, iron, double.
4	blocks, iron, treble.
2	blocks, wood, snatch.
9	chocks, gun.
68	chocks, roller.
112	chocks, wheel.
2	capstans and bars.
2	derricks.
1	collar for 15-inch gun.
1	cradle for 15-inch gun.
1	capstan or crab, geared.
15	skids.
38	rollers, long.
14	rollers, short.
34	shifting planks.
7	sling chains.
7	shot beds, wooden.
5	wrought iron shot frames.
6	way planks.
24	fencing bayonets.
1	plane table.
2	platforms for mortars.
12	platforms for siege carriages.
10	platforms, field and rail.
127	shot marks.
7,649,000	pasters.
57,600	paper targets.
83	Laidley revolving targets.
24	disks.
12	disk staves.
12	signal flags with staves.
308	signal flags for rifle range.
21	targets, truck.
293	streamers for rifle range.

CLASS X.

12	cap squares, field.
2	counter hurters for 8-inch carriages.
136	parts of Laidley cavalry forges.
6	poles for field and siege carriages.
10	nuts.
40	washers.
2	sponge hooks.

100 straps for ammunition chests.
50 pole-prop straps.
2 anvils for cavalry forges.
3 artillery collars.
58 halter straps.
2 pole pads.
5 pendulum hausse seats.
7 rammer heads for 10-pounder Parrott and 3-inch gun.
3 sponge heads for 10-pounder Parrott and 3-inch gun.
6 sponge heads for 6-pounder field gun.
6 sponge heads for 4.5-inch rifle gun.
108 woolen sponges for field guns.
200 tin straps for 15-inch shot and shell.
2 barrels for Springfield rifled muskets.
7 bayonets, cadet rifles.
1 front sight, cadet rifle.
1 front sight-pin, cadet rifle.
1 "Bull's" Vernier and wind-gauge sight.
626 parts of Hotchkiss carbines or rifles.
78,980 spare parts for Springfield rifles.
6 springs for rod bayonet.
18 stocks for fencing muskets.
1 stock for officer's rifle.
6 scabbards for cadet swords.
1 lower band for foot officer's sword.
50 coat straps.
12,010 canteen covers.
20,000 brass bar buckles.
12,000 brass wire buckles, ¾-inch.
80 canteens, covered, dyed duck.
2,000 clothing-bag straps.
9,000 canteen corks and chains.
200 hook straps for brace yokes.
10 haversack straps.
1,197 leathers for altering cartridge belts.
1,200 snap-hooks for saber belts.
1,000 springs for carbine-sling swivels.
1 bridle rein.
170 carbine sockets.
608 coat straps.
24 double S hooks.
65 curb straps.
100 girth straps, long.
70 cincha straps.
8,700 hooks, snap, double spring.
112 headstalls for bridles.
5,000 backs and handles for horse brushes, leather.
48 fasteners for side lines.
100 girth billets.
300 rings, brass, ⅞ inch in diameter.
85 rings, iron, 2½ inches in diameter.
2,724 rings, D.
48 halter bolts.
73 ovals, guard plate.
1,668 halter rings.
60 halter squares.

281	halter straps.
3,300	spring snaps.
40	safety straps for saddle bags.
516	brass staples for rings.
2,000	brass foot staples.
1,000	saddle-bag studs.
70	wooden stirrups.
68,305	cartridge bags, empty, various.
1,000	cartridge shells, revolver.
5,000	cartridge shells, rifle.
3,000	cartridge caps, primed.
6,586,000	cartridge primers.
31,700	cartridge shells, primed.
2,145	cartridge shells, primed, Hotchkiss.
28,629	cartridge shells, primed, shot gun.
2,100,000	cartridge wads, carbine.
2	poles for hand-sling carts.
4	iron pins for capstan.
258	parts of targets.

MISCELLANEOUS.

1,772	arm chests.
2,891	packing boxes.
395	tin cans.
40	iron boxes.
1	tin packing box.
16	Madigan boxes.

TOOLS.

4	aprons, smiths'.
1	boat.
3	wire scratch brushes.
6	chamois-skin cases.
1	instrument case.
203	chisels, assorted.
279	chisels, metal turning.
3	barrels coal-tar.
13	drawings.
1,222	drills.
1,100	pressure disks.
2	drifts.
1,398	dies, assorted.
32	extractors, primer.
2,055	files, assorted.
241	files, rotary.
10	formers, rockets.
305	funnels, copper.
2	horses, saddlers'.
1	heading tool, double.
1	indenting tool, pressure gauge.
2	ladders.
6,930	pounds lubricant.
1	mallet.
6	iron mauls.
1	opisometer.
601	primer-extractor pins.

313 priming tools.
3 pressure gauges, internal.
6 pressure scales, diagonal.
559 powder chargers.
24 paint pots.
9 reloading hand punches.
688 punches, assorted.
1 punch, resizing.
100 steel plates for cleaning-material boxes.
50 steel plates for cleaning buttons and ornaments.
78 arm racks.
8 seal stamps.
16 sets letter stamps.
1 wheelbarrow.
481,320 pounds alloy for bullets.
775 cast-iron tablets for soldiers' graves.
116 rollers for painting tablets.
31 augers.
67 bits,
8 calipers.
1 tool for marking and cutting cartridge-bag material.
1 caliper for rifle projectiles.
1 book case.
2 quarts browning mixture.
2 pounds polishing material.
240 ounces leather polish.
80 ounces scouring material.
1 disjunctor for electro-ballistic pendulum.
1 dynamometer, hydrostatic pressure.
100 elements, zinc, for galvanic battery.
100 faking boxes, for life-saving service.
1 star gauge.
28 gauges, assorted.
100 gas checks.
100 pounds wheel grease.
1 gauge, cartridge tool.
1 set gauges, chamber and cartridge for shot-gun.
1 gauge, front sight.
1 set gauges, cartridge primer.
1 gauge, electric primer box.
1 gauge, friction primer box.
2 sets gauges, No. 20 cartridge shells.
20 gallons lacker.
6 lead furnaces.
216 mills, armorers'.
1 cartridge heading machine.
2 cartridge head trimming machines.
1 cartridge pocket sizing machine.
1 cartridge venting machine.
1 cartridge press.
1 set plates and tools for inserting anvil.
6,322 pounds harness oil.
5,405¾ pounds paint, various.
483½ pounds putty.
2 brass rules for measuring pressures.
4 paper stencils.

4 magazine slippers.
110 pounds solder.
1 copper scoop.
1 copper shovel.
521 stoves for Quartermaster's Department.
377 parts of stoves.
3 iron doors for Quartermaster's Department.
5 cast-iron posts.
23 screw taps.
14 thimbles for rope.
1 tool bag.
165 parts of tools for reloading cartridges.
106 sets of tools, hand, for reloading cartridges.
1 spring wagon and cover.
2,635 tools for current service.
82½ gallons shellac varnish.
2 shafts for circular saw.
98 pounds sealing wax.
1 sideboard for post.
40 pounds black wax.
6 teeth for Winchester reloader.
1 lever scales.
16 tree guards.

APPENDIX 2.

***Statement of principal articles procured by purchase at the arsenals during the year ended June* 30, 1882.**

CLASS I.

2 Gatling guns, 10 barrels, long, caliber .45, model 1881.
3 breech-loading chambered rifles, caliber 3.20.
4 Hotchkiss revolving cannons, caliber 1.5 inch.
2 steel parts 11-inch rifle from 15-inch smooth-bore Rodman gun.

CLASS II.

4 carriages and limbers for Hotchkiss revolving cannon, caliber 1.5 inch.
1 upper carriage and chassis for 12-inch breech-loading chambered howitzer.

CLASS III.

50 breech sights.
100 paulins, 12 by 15 feet.
12 woolen sponges, 3-inch rifle.
1 vent piece.
2 pendulum hausse pouches.
5 scrapers.
4 sets of implements for Hotchkiss revolving cannon.
2 sets of implements for Gatling gun, caliber .45.
2 loading machines for Hotchkiss mountain gun.

CLASS IV.

45 10-inch Butler cored shot.
600 8-inch Butler cored shot.
50 8-inch Butler muzzle-loading shot.
104 11-inch Hotchkiss breech-loading shot.
25 8-inch Hotchkiss breech-loading shot.
20 3.20-inch Hotchkiss breech-loading shot.
70 8-inch Eureka muzzle-loading shot.
4,000 1.5-inch Hotchkiss shell, percussion fuse.
5,000 rounds Hotchkiss ammunition.

CLASS VI.

1,000 Colt's revolvers, caliber .45.
20 Parker's breech-loading shot guns.

CLASS VII.

4,014	blankets, cavalry, gray.
3,305	curry-combs.
1	bridle.
2	halters.
2	halter straps.
104	pairs stirrups.
25	horse brushes.
6	horse cards.
6	hame straps.
65	lariats.
1	shot pouch.
1	powder flask.
11,584	knives.
11,584	forks.
11,632	spoons.

CLASS VIII.

70,525	pounds musket powder.
59,700	pounds hexagonal powder.
1,000	pounds cannon powder.
353,000	rifle ball cartridges, caliber .45.
500	cartridges, Winchester gun, caliber .44.
500	cartridges, magazine gun, caliber .45.
1,150,000	cartridges, Creedmore, caliber .45.
1,000	cartridges, caliber .55.
6,650	feet safety fuze.
850	shot-gun shells.
633,250	shot-gun wads.
4,000	Berdan caps.
200,000	metal primed caps.
3,000	primers.
2	boxes primers.
15,750	pounds drop shot.

CLASS IX.

13	single blocks.
13	double blocks.
3	pulley blocks.
2	brass trunnion rings.
20	cast-iron sheaves.
5,174	marksmen's buttons.
1	chronograph.

CLASS X.

210	parts of artillery harness.
27	curb-bits.
3	firing pins, Gatling gun.
50	11-inch Hotchkiss sabots.
55	10-inch Butler sabots.
127	8-inch Butler sabots.
12	8-inch Hotchkiss sabots.
5	screw plugs.
7	saddle trees.
344	Hotchkiss stocks.

35	Hotchkiss horn tips.
75	spokes.
25	felloes.
130	assorted stocks.
250	wiping rods.
24	cleaning rods, shot-gun.
3, 044, 290	Winchester cartridge primers.
4, 000	cartridge cases, Hotchkiss revolving cannon, 1.5 inch.
4, 000, 000	primed caps.
262	parts of revolvers.
200	parts of shot-guns.

MISCELLANEOUS.

85½	yards bunting.
211	yards burlaps.
2	yards blue serge.
3, 794	yards binding braid.
984	pieces binding braid.
1	gross buttons.
642	yards cotton cloth.
1, 079¼	yards enameled cloth.
24¼	yards oil cloth.
24	yards rubber cloth.
68¾	yards wool cloth.
90¾	yards petersham cloth.
2⅔	pieces green cloth.
1	piece rubber cloth.
77½	yards carpeting.
17, 345¼	yards cotton duck.
2	pounds cotton batting.
11	gross cotton web.
6, 951½	pounds cotton waste.
57	square yards cotton duck.
26	yards cotton cord.
332	pounds sash cord.
18	pieces sash cord.
730½	pounds hair cord.
49	pounds assorted cord.
8	pounds "clare fiber."
245¼	yards wool flannel.
166¾	yards canton flannel.
8	yards hollands.
986	yards felt cloth.
9	pounds moss.
457	yards matting.
45	pounds marline.
10	yards muslin.
200	pounds ixtle.
60	pounds oakum.
1½	pounds cotton rope.
38, 351¼	pounds manila rope.
148	pounds hemp rope.
820	pounds hair rope.
22	pounds tarred rope.
2	bales oakum.

30½	pounds sewing silk.
3	spools sewing silk.
35	pounds sheep-skin clippings.
100	feet steam-pipe covering.
100	pounds tow.
1	yard ticking.
1,538	pounds thread.
42	spools thread.
9	balls twine.
572½	pounds twine.
10	yards velvet.
2	yards velveteen.
4,257½	yards webbing.
6,482	pieces webbing.
11	pounds woolen yarn.
10	window curtains.
6	window shades.
87	pounds hair thread.
2,224¼	yards cotton twills.
12,614	pounds barley.
24,341	pounds bran.
1,542⁵⁄₇	bushels corn.
170	bushels corn meal.
28,145	pounds corn meal.
16½	bushels grass seed.
271,688½	pounds hay.
22½	tons hay.
4,882⅜	bushels oats.
51,387½	pounds oats.
23	barrels flour.
9,520	pounds ground feed.
50	pounds oil meal.
122	barrels salt.
13¾	bushels salt.
275	pounds salt.
1	sack salt.
50	pounds rock salt.
62,527½	pounds straw.
25	pounds babbit metal.
12	buckets for chain pump.
2	box scrapers.
792	back flaps.
25	wash-basins, iron.
473	blind and window fasteners.
283	window and door bolts.
1,500	pounds iron bolts.
6,865	iron bolts.
23	pounds bolts and nuts.
8	iron boilers.
228	papers brads and nails.
5,170¼	pounds sheet brass.
1	piece sheet brass.
78½	pounds brass rods.
2,199¾	pounds brass castings.
6	electric buttons.
114,673	pounds iron castings.

30	iron castings.
259¼	pounds composition casting.
1	casting.
72	casters.
66	catches, assorted.
46	clamps, assorted.
297	feet chain.
3,306½	pounds chain.
192	pieces chain.
104	cocks, assorted.
382¾	pounds bar copper.
146,494½	pounds sheet copper.
62½	pounds copper pipe.
22	chest handles.
118	couplings for pipe.
17	couplings for hose.
16	iron doors.
150	door knobs.
57	door springs.
15	door fixtures.
54	escutchions.
187	pounds escutchion pins.
1,967	elbows, &c., for pipes.
48	eyelets.
2¼	pounds ears for kettles.
132	ears for kettles.
7¼	pounds gas fittings.
79	gas fittings.
1	gas retort.
271½	feet gas pipe.
2	papers glaziers' points.
9	sets grate bars.
447	pounds grate bars.
7⅛	pounds German silver.
48	pennyweights gold.
1	pack gold leaf.
1	globe ventilator.
8	gauge glasses.
4,170	horseshoes.
1,801¾	pounds horseshoes.
4	kegs horseshoes.
1	hydrant.
1,580	pairs hinges.
2,307	hooks, assorted.
799	hooks and eyes.
12	hinge plates.
53	hinge hasps.
6	hasps and staples.
1	hanger frame.
1,412½	pounds iron shafting.
211	pounds iron staples.
1,187,966	pounds iron, beam.
173	pounds iron, channel.
250	pounds iron, angle.
242	pounds iron, T.
5,040	iron halter squares.

144	iron screw eyes.
6	iron washers.
70½	pounds iron washers.
39	pounds iron burrs.
71,460¼	pounds iron, bar.
11,172½	pounds iron, sheet.
30	iron braces.
6,628	pounds iron nuts.
317	iron nuts.
98	iron pulleys.
12,821	pounds iron pipe.
8,418 1/12	feet iron pipe.
5,317	pounds iron, hoop.
2,137	iron rings.
70	iron rollers.
15,126	iron buckles.
1	iron sheave.
1	set iron capstan screws.
1,104¼	pounds iron, galvanized.
2	iron tanks.
2	iron hitching posts.
1,800	feet iron rope.
4,695	pounds iron, plate.
25	tons iron, pig.
1	iron kettle.
46	drawer knobs.
3	keys.
128	keys and blanks.
748	locks.
233½	pounds lead, scrap.
1993½	pounds lead, sheet.
4,228	pounds lead, pipe.
16	lead S traps.
10	sheets mica,
¼	pound mica.
40,591	pounds nails.
8	gross saddlers' nails.
4	papers japanned nails.
36	carriage nails.
1	fire plug.
254	plugs, assorted.
5	pinions.
3	pumps.
3	fire pots.
9	plane irons.
24	rings and staples.
76,833	rivets.
189¼	pounds rivets.
2,355	pounds rivets and burrs.
329	radiators.
3,384	feet safety chain.
4	spiral springs.
12	spring catches.
16	springs and fixtures.
1,380	feet steam pipe.
1	steam whistle.

3	steam boiler connections.
2	ounces silver solder.
1	cast-iron socket.
10	shaft-hangers.
144	staples.
12	screw-caps.
85	pennyweights silver.
7	steel plates.
8	sets steel dies.
6, 915¾	pounds steel, bar.
7, 581¼	pounds steel, sheet.
3	steel pins.
1, 129	pounds steel forging.
8, 165¼	pounds steel, cast.
2, 010	pounds steel, plate.
392	pounds steel, spring.
1, 203	pounds steel, machine.
582	pounds steel axles.
7	steel disks.
440, 235	pounds steel, gun.
20	snaps.
2	spur wheels.
3, 485¾	gross screws.
4, 977	screws.
2, 709	pounds spikes.
304½	pounds solder.
6	gross screw tops for cans.
242½	pounds swivels.
285⅓	gross screw pins.
20	shade fixtures.
1	set stair rods.
2	pounds blind staples.
4	wagon springs.
69¼	pounds wagons springs.
100½	pounds brass tubing.
15	feet assorted tubing.
20¼	pounds assorted tubing.
14¼	pounds type.
726, 000	iron tacks.
235	pounds iron tacks.
68	pounds copper tacks.
6, 170	copper tacks.
84	papers copper tacks.
31, 627	pounds block tin.
221	boxes sheet tin.
148	pounds sheet tin.
68	sheets tin.
135	pounds tin-foil.
535	papers tacks.
2	iron tail gates.
55	thumb-latches.
4, 056	valves, &c.
1	pound German silver wire.
1, 096⅔	feet wire cloth.
690⅚	square yards wire cloth.
747½	square feet wire gauze.

424	feet wire netting.
10,071	pounds brass wire.
1,918	feet brass wire.
7,902¾	pounds copper wire.
200	feet copper wire.
209	feet platinum wire.
527¾	pounds steel wire.
7,611¼	pounds iron wire.
1,000	feet covered wire.
21½	pounds covered wire.
20¼	pounds Birmingham music wire.
1,895	pounds barbed wire.
3,352	feet wire rope.
150	feet wire cord.
1	coil wire.
2	sheets zinc.
1,752½	pounds zinc.
12	window fixtures.
11	pipe fixtures.
4	iron sinks.
240	gas fixtures.
15	water closets.
67	water closet fixtures.
4	gas meters.
22,748	square feet leather, bag.
7,976¾	square feet leather, bellows.
4,720½	feet leather belting.
961¼	square feet leather, bridle.
1,001	sides leather, bridle.
13	pounds leather, bridle.
138¾	square feet leather, russet.
3	sides leather, russet.
97,919¾	square feet leather, collar.
53,230¾	pounds leather, harness.
3	sides leather, harness.
73	sides leather, lace.
4½	pounds leather, lace.
36	leather lacings.
3,218½	pounds leather, nose-bag.
13	sides leather, alum-tanned.
4	square feet leather, oak-tanned.
36¾	pounds leather, sole.
4	square feet leather, sole.
2¼	sides leather, sole.
116	square feet leather, top.
24¼	pounds leather, walrus.
6,972	balls black wax.
81	quarts blacking for leather.
2	pounds black wax.
1	piece rawhide.
49½	feet rubber belting.
1	goat-skin.
7	sheep-skins.
600	feet rawhide lacing.
4	yards head lining.
2,172	feet hose.

1,018	pounds Okatka bristles.
800	feet belt lacing.
3,216½	feet leather, collar.
161	square feet leather, alum-tanned.
771,998	feet boards.
110	pieces board.
1,175	battens.
10,521	feet battens.
24,224	feet lathes.
10,212	lathes.
3,588	feet posts.
1,048	feet posts and piles.
150	rails.
200	pickets.
213,800½	feet plank.
88	pounds rosewood.
398,850	shingles.
127,102	feet scantling.
180,403	feet timber.
990	feet weather strips.
10	pounds alabastine.
776,264	bricks.
19,118⅓	square feet bricks.
50	brackets.
4,176	barrels cement.
4	casks cement.
8	chimney crocks.
6	barrels calcined plaster.
177	feet cement pipe.
9	columns.
56	doors.
1	door frame.
7	elbows for drain pipe.
94	barrels fire-clay.
10	bushels fire-clay.
30	sets fire-brick.
4	sets fixtures for blinds.
5	bushels fire-sand.
160½	loads gravel.
45	boxes glass.
1,641	lights glass.
75½	square feet glass.
1,522	feet glass.
1,063⅓	feet gutters, &c.
321	pounds plastering hair.
8	bushels plastering hair.
12,369	square feet iron roof.
386	loads loam.
1,820½	barrels lime.
919½	bushels lime.
4,538½	feet moldings.
291	pounds tarred paper.
20	rolls tarred sheathing paper.
248	rolls wall paper.
314	yards bordering paper.
50	pounds plaster of Paris.

114⅛	barrels plaster of Paris.
182	feet sewer pipe.
1¼	bushels plaster of Paris.
88	loads rocks.
28	rolls roofing felt.
5, 187	slates.
836	square feet slates.
692	sewer pipes, &c.
50	barrels shells.
704	barrels sand.
1, 313½	cubic yards sand.
25	loads sand.
3, 867	pounds sand.
30	sacks sand.
1	ton sand.
17, 407½	square feet stone flagging.
62	fire-clay tiles.
59	yards terra-cotta pipe, &c.
12	terra-cotta pipes.
16	sets window-blinds.
111	window-sash.
81	window-shutters.
16	window-frames.
43	window-blinds.
14	spokes.
295	tons stone.
2	barrels kaolin.
2, 716¾	cubic yards stone.
30	feet earth elbows and pipe.
110	fire brick.
2¾	pounds asbestos packing.
37	pounds asbestos paper.
1	gallon browning mixture.
1, 021	brooms.
61	dust brushes.
47	brushes, assorted.
5	basins.
14	buckets and pails.
1, 102$\frac{220}{2240}$	tons bituminous coal.
2, 356, 425	pounds bituminous coal.
1, 187$\frac{1912}{2240}$	tons anthracite coal.
1, 280, 001	pounds anthracite coal.
24, 780	pounds gas coal.
105	tons coke.
19	bushels coke.
10	sacks charcoal.
179	barrels charcoal.
30, 539½	bushels charcoal.
124	chamois skins.
2	quires crocus cloth.
530	pounds corundum.
159	square feet card-clothing.
30	sheets card-clothing.
262	pounds candles.
6	carats diamond powder.
3, 029	pounds emery.

9	reams emery cloth.
362	quires emery cloth.
50	quires emery paper.
2	furnaces.
58	furnace fixtures.
18	fire-grates.
3	fire-pots.
140½	cords wood.
1	fire-back.
54	fixtures, assorted.
32,033	pounds ground bone.
184	pounds ground glass.
4	gas ovens.
7,406½	gallons gasoline.
395	feet hair felt.
2	quarts harness polish.
3	lamps.
190	lamp chimneys.
18	lamp fixtures.
69	balls lamp-wicks.
60	lamp-wicks.
44	pounds lamp-wicks.
50	lanterns.
47	lamp-shades.
22	lamp-burners.
28½	gross matches.
3	cases matches.
5	mats.
516	pounds mineral facings.
720	pounds machine facings.
524⅝	gallons naphtha.
25	gallons astral oil.
1	gallon polishing oil.
32	pounds pumice stone.
52⅕	gallons paraffine.
35	pounds paraffine.
25	pounds quartz.
5	ranges.
9	registers.
5	register fixtures.
950	pounds rotten-stone.
18	stoves.
81	stove fixtures.
30	feet stove-pipe.
10	pieces stove-pipe.
38½	pounds stove-pipe.
150	quires sand-paper.
61	reams sand paper.
25 5/32	barrels soap.
3,081¼	pounds soap.
1	box soap.
61	cakes soap.
195½	pounds sponge.
3	pieces sponge.
75	barrels sea-coal facings.
4	tons sea-coal facings.

28	papers stove-polish.
27	pounds stove-polish.
2½	quarts silver polish.
4	pounds spermaceti.
181	papers tripoli.
6	torch lighters.
1	tile hearth.
4	ventilators.
3	gallons water-proof polish.
158½	pounds whiting.
137	bath-bricks.
45	emery wheels.
122	blank books.
23	books.
84	sheets bristol board.
79	pounds binder's board.
4	blotting pads.
2	blotter baths.
750	blank slips.
2	blue tapes for stamps.
1	brush for press.
18	baskets.
1	book-case.
1	gross crayons.
1	box crayons.
3,025	sheets card-board.
7,100	cards, assorted.
1	call-bell.
12	camel-hair pencils.
29	chairs.
28	cocoa mats.
162	pounds composition.
4	clocks.
2	pans drawing paint.
4	desks.
1	box draughting paint.
12	draughtsman's materials.
83,100	envelopes.
14	boxes eyelets.
40	erasers.
4	electrotype plates.
2	figures.
3	sets figures.
200	goose-quills.
2	cans hektograph filling.
128½	quarts black ink.
125	bottles red ink.
10	sticks india ink.
637	pounds printing ink.
1	bottle hektograph ink.
6	bottles drawing ink.
3	bottles ink for stamps.
26	inkstands.
6	bottles ink-eraser.
1	invoice file.
1	letter-press.

2, 170	lead-pencils.
18	leads for pencils.
6, 550	labels.
2, 171	letters.
9	sets letters.
1	looking-glass.
41½	quarts mucilage.
8	mucilage stands.
12	memoranda blocks.
2	maps.
2	bottles ox galls.
100	sheets oil-boards.
327½	reams writing-paper.
92	quires blotting paper.
18	sheets blotting paper.
114¾	reams wrapping paper.
25	sheets oil paper.
143	pounds drawing paper.
2	rolls drawing paper.
66	sheets drawing paper.
28, 622	pounds Manila paper.
3	gross paper fasteners.
500	paper-fasteners.
18	boxes paper fasteners.
2, 000	paper dials.
1, 400	sheets ruled paper.
8	paper cutters.
75	paper bags.
6	sheets tracing paper.
2	pen racks.
6	paper weights.
12	indelible pencils.
426	pounds petroleum paper.
4	pitchers, basins, &c.
25	sheets albumenized paper.
4	reams envelope paper.
1	box pins.
3	pounds pins.
119	gross pens.
180	pen-holders.
1	gross pencil-point protectors.
24	pencil sharpeners.
81½	gross rubber bands.
2	pounds erasing rubber.
73	india rubbers.
7, 062	yards red tape.
2	ribbons for type-writer.
2	pounds red tape.
5	spools red tape.
1	ribbon for stamp.
3	rulers.
69	stencil boards.
197¾	pounds sealing wax.
3	stamp pads.
18	sponge cups.
50	yards silk tape.

4	pairs shears.
1	quire shipping receipts.
1	slateograph.
4	boxes seals.
8	spittoons.
2	slop pails.
2	scale guards.
174	yards tracing cloth.
3	rolls tracing cloth.
49	gross thumb-tacks.
24	thumb-tacks.
10, 400	tags, assorted.
1	piece tracing cloth.
12	tablets.
1	table.
2	boxes wafers.
2	water coolers.
1	wash-stand.
19, 600	blank forms.
144	sheets paper for blotter bath.
1, 551	pounds wrapping paper.
3	reams hektograph paper.
4	stamps.
625¼	gallons alcohol.
15½	pounds alum.
¼	pound arnica.
3	pounds arnica flowers.
33	pounds antimony.
9, 409	pounds sulphuric acid.
15½	gallons carbolic acid.
127½	pounds muriatic acid.
1⅞	gallons muriatic acid.
1	jar muriatic acid.
1	jar sulphuric acid.
½	gallon nitric acid.
1, 783	pounds nitric acid.
½	pound salicylic acid.
1	pound oxalic acid.
50	pounds ammoniated copper.
262	pounds aqua ammonia.
1	gallon arnica tincture.
1	barometer.
2	wooden bowls.
1	box browning material.
88½	pounds borax.
54	pounds bichromate of potash.
144½	pounds beeswax.
4¾	reams black paper.
7	quarts browning.
6	bottles.
1	bell jar.
117, 964	pounds bone.
124	pounds chalk.
50	galvanic battery cells.
112	pounds camphor.
356	pounds chlorate of potash.

12	pounds of concentrated lye.
73	cans concentrated lye.
6	pounds carbonate of iron.
6	pounds chloride of calcium.
4½	pounds collodion.
$\frac{1}{32}$	pound cobalt carbonate.
$106\frac{6}{12}$	gross corks.
6	pounds corrosive sublimate.
8	carboys.
20	pounds carbonate of lime.
1	pound cyanide potash.
1	pair crucible tongs.
3	square feet copper gauze.
1	copper vessel.
12	porous cups.
230	pounds chloride of lime.
25	pounds corundum.
11	pounds assorted chemicals.
12	bottles dry gold.
573	pounds electropian fluid.
22	rolls ferro-prussiate paper.
50	pounds flax-seed meal.
26¼	pounds glycerine.
⅛	gallon glycerine.
2,905½	pounds glue.
240	pounds gum arabic.
152	pounds gum dextrine.
30¾	pounds gum tragacanth.
2	glass tubes.
7	pounds Glauber salts.
1	package horse powders.
10	bottles horse medicine.
2	jars.
1	bottle liniment.
6	lead-melting pots.
3	pounds lard.
8	pounds mercury.
3	pounds muriate of iron.
½	gallon molasses.
122	pounds nitrate of strontia.
$\frac{1}{16}$	pound nickel oxide.
6	ounces nitrate of nickel.
¼	gallon oil of tar.
3	pounds prussiate of potash.
15	pounds proto-sulphate of iron.
32	pounds pepper.
2	barrels pitch.
10	pounds potassium.
2	rolls photographic paper.
1,995	pounds potash.
24	cans potash.
4	potash bulbs.
6	balls potash.
2	platinum cones.
1	platinum bottle.
1	platinum boat.

1	platinum crucible.
8	inches platinum wire.
30	grains platinum scrap.
2	retorts.
66	rubber stoppers.
21	feet rubber tubing.
92	pounds sal ammoniac.
656	pounds sulphate of copper.
74	pounds spirits of niter.
12	pounds saltpeter.
50	pounds soda.
6,177	pounds sal-soda.
28	pounds sulphur.
28,530	pounds straw-boards.
2	bundles straw-boards.
2	ounces sulphuric ether.
16	gallons sirup.
279	pounds silicate of soda.
200	pounds sulphate of iron.
100	pounds soda ash.
100	pounds sugar of lead.
6	gallons tar.
20	pounds tobacco.
¾	pound tin tarter.
498	gallons turpentine.
2,533	pounds tallow.
48	test tubes.
3	pounds tubing.
2	pounds Venice turpentine.
½	pound tincture iodine.
8	thermometers.
16	gallons vinegar.
1	vacuum pump and blast.
1	bottle vaseline.
30¼	gallons whisky.
1,589	pounds Japan wax.
12	zincs.
59	gallons glue.
46	barrels coal-tar.
2	pounds chloride of ammonium.
2	ounces ointment.
8	bath-tubs.
14	bath-tub fixtures.
100	pounds powdered charcoal.
208	gallons benzine.
71	pounds burnt sienna.
253	pounds burnt umber.
59	pounds chrome green.
148	pounds chrome yellow.
24	barrels coal-tar.
2	gallons coal-tar.
461	pounds copperas.
15	quarts cosmoline.
136¼	gallons Japan drier.
161	pounds black drop.
27	pounds extract of logwood.

760	pounds French yellow.
100	pounds machine grease.
37	pounds ivory black.
732½	pounds lampblack.
640	pounds red lead.
25, 792	pounds white lead.
44	pounds black lead.
422	pounds litharge.
2	ounces liquid gold.
4	ounces liquid gold lacker.
7	pounds nut-galls.
51	gallons naphtha.
726½	gallons kerosene oil.
3, 029½	gallons linseed oil.
2, 738½	gallons lard oil.
399	gallons machine oil.
160¾	gallons neat's-foot oil.
102	gallons olive oil.
2, 894¼	gallons sperm oil.
165	gallons cod-liver oil
13¼	gallons castor oil.
257½	gallons clami oil.
152	gallons coal oil.
42	gallons astral oil.
2	bottles clock oil.
5	gallons wool oil.
50½	gallons cosmoline oil.
53	gallons headlight oil.
40	gallons mineral oil.
8, 118¼	pounds metallic paint.
2, 025	pounds olive paint.
1, 099	pounds black paint.
34½	pounds brown paint.
1, 577½	pounds red paint.
87	pounds green paint.
52	gallons green paint.
4½	gallons lithogen paint.
3½	gallons metallic paint.
400	pounds mineral paint.
302	pounds lead-color paint.
6	gallons assorted paints.
1, 065½	pounds assorted paints.
18	pans assorted paints.
7	bottles assorted paints.
140	gallons fire-proof paint.
5	gallons copper paint.
14	pounds Paris green.
23½	pounds Prussian blue.
1	gallon pine-tar.
268¼	pounds putty.
15	barrels pitch.
80	pounds rosin.
50	pounds rouge.
2	pounds red chalk.
490	pounds shellac.
¾	gallons shellac.

9	gallons turpentine.
128	pounds Venetian red.
30½	pounds vermilion.
110	gallons copal varnish.
13½	gallons coach varnish.
174	gallons Japan varnish.
1	gallon varnish, patent drier.
2	gallons asphalt varnish.
125¼	gallons assorted varnish.
2, 270	pounds whiting.
1, 328	pounds gilder's whiting.
6¼	pounds wax.
2, 730	pounds yellow ocher.
200	pounds zinc.
50	gallons valsoline.
170	pounds kalsomine.
16	packs kalsomine.
422	pounds Paris white.
5	gallons asphaltum.
1	barrel rosin.
6	awnings.
6	axles.
157	packing boxes.
14, 501	tin boxes.
406	barrels.
1	boat sail.
1	boat cushion.
433	brushes, assorted.
2	gross buttons.
23	baskets.
3	bells.
8	bowls, pitchers, &c.
109	buckets, pails, &c.
26	tin cans.
1	drinking cup.
6	powder canisters.
12	cuspidors.
1	clock.
5	carriage fixtures.
2	chair bottoms.
1	coal screen.
1	diaphragm ring.
1	drag.
5, 000	dials for watch clock.
1	pair drum sticks.
1	flag.
6	flower pots.
448	pounds wheel grease.
48	boxes wheel grease.
250	pounds gutta percha.
8	gum gaskets.
6	sets post harness.
5	gross clothes hooks.
8	horses.
36	harness pegs.
2	horse aprons.

2	horse boots.
5	pounds hemp packing.
4	hose reels.
6,551	pounds ice.
40	insulators and brackets.
335⅞	pounds assorted joint packing.
38	jars, jugs, &c.
2	jackets.
4,441¼	pounds Japan wax.
100	kegs.
19	lawn sprinklers.
1	leather seat for sleigh.
1	set letters.
100	copies of newspapers.
5	pair oars.
2	pair overalls.
3	oil-stone slips.
2	permanent plants.
7	pumps.
14	pump fixtures.
2	paper files.
1	pressure blower.
60	parts of mowing machine.
196	parts of harness.
115	parts of wagons.
23	parts of engines.
25	white-oak rollers.
3	yards rubber packing.
1	font rubber type.
44	pounds rubber car-springs.
1	rubber coat.
23	rubber springs.
⅒	pound rubber tubing.
1,088	feet rubber tubing.
22	pair rubber boots and shoes.
36,934	pounds rubber packing.
7	rolls ribbon.
10	rollers for press.
4	skiffs.
5	yards sponge-head material.
150	8-inch sponge leaves.
1	set scales.
24	saucers.
4	sieves.
2	loads saw-dust.
81	barrels saw-dust.
2	screens.
1	string sleigh-bells.
10	stencils and plates.
28	pair slippers.
41	stamps.
1	scale and weights.
12	telephone cords.
12	telephone connections.
2,377	trees, shrubs, &c.
2	strings trotting balls.

6	wagons.
91	wheels.
9	watering-pots.
5	wood-cuts.
11	whips.
12	whip-sockets.
1	water-filter.
1	leather satchel.
1	steam launch.
2	scratch brushes.
1	flue scraper.
1	blasting machine.
2	boring machines.
1	crushing machine.
1	corn sheller.
1	drilling machine.
1	double-chain hoist.
6	electrotypes.
1	engineer's transit.
2	engine lathes.
1	enumerator.
1	face plate.
1	force pump.
1	feed cutter.
1	flue cleaner.
1	incline press.
1	instrument for measuring elongation.
2	lathe chucks.
1	mason's hygrometer.
2	magnetic call boxes.
2	objectives for microscope.
1	specific gravity apparatus.
3	paint mills.
1	scroll chuck.
1	steam pump.
1	stalk cutter.
2	sewing machines.
1	windmill.
1	mortising machine.
1	grinding machine.
3	lathes.
6	milling machines.
1	cooler and heater.
1	cartridge shell reloader.
7	hydraulic jacks.
1	Lyons' handshears.
1	mold for forming leather packings.
64	parts of mowers.
1	pound, part of mower.
1	primer loading press.
1	primer capping press.
1	charging machine.
1	varnishing machine.
1	steam boiler.
1	traveling crane.
2	anvils.

62 axes.
1,530 brushes.
10 blocks.
120 belt fasteners.
6 belt shifters.
14 chalk lines.
176 pounds chalk lines.
18 coal-hods.
16 ash cans.
3 coal-sifters.
10,000 clamps.
2 extracting primers.
250 extractor levers.
250 extractor hooks and pins.
250 extractor lever screws.
2,485 files.
21 hay forks.
4 grindstones.
63,571 pounds grindstone.
14 hammers.
1,081 handles.
274 knives.
2 ladders.
121 ladles, 7 inch.
1 ladle, stamped.
121 ladles, 2½ inch.
24 level glasses.
33 mowers.
66 needles.
112 papers needles.
23 oil stones.
26 picking carriages.
157 priming tools.
1 powder and shot measure.
1 plowshare.
1 plow.
1 part of sewing machine.
1 road scraper.
106 rakes.
10 spirit levels.
112 scythe and sand stones.
25 shell holders for priming tools.
76 shovels, spades, &c.
2 speed indicators.
27 scythes, &c.
5 scales.
11,932 tools, various.
5 tape lines.
6 vises.
1 milling wheel.
4 water gauges.
51 wheelbarrows.
40 saws.
34 utensils, various.
2 sets tools.

APPENDIX 3.

Statement of ordnance, ordnance stores, &c., issued to the military establishment, exclusive of the militia, during the fiscal year ended June 30, 1882.

CLASS I.

2 Gardner guns, caliber .45.
4 Gatling guns, caliber .45, 10 long barrels.
4 Gatling guns, caliber .45, 5 short barrels.
7 Hotchkiss revolving guns, caliber 1.5 inch.
3 Hotchkiss mountain guns, caliber 1.65 inch.
1 6-pounder bronze gun.
6 3-inch rifled guns.
2 heavy 12-pounder guns.
4 30-pounder Parrott guns.
4 4.5-inch siege guns.
1 8-inch converted rifled gun.
3 8-inch siege howitzers.
2 24-pounder Cohorn mortars.
1 8-inch siege mortar.
2 10-inch siege mortars.

CLASS II.

9 Gatling gun carriages.
2 1.5-inch Hotchkiss revolving gun carriages.
8 1.65-inch Hotchkiss mountain-gun carriages.
16 6-pounder 3-inch and 10-pounder gun carriages.
11 light 12-pounder gun carriages.
6 4.5-inch siege-gun carriages.
1 8-inch converted-gun carriage and chassis.
3 8-inch siege-howitzer carriages.
1 8-inch siege-mortar bed, iron.
2 10-inch siege-mortar beds, iron.
8 3-inch gun caissons.
1 Laidley cavalry forge cart.
9 portable cavalry forges.
2 tripods for Gatling gun.
1 mortar wagon.

CLASS III.

9 budge barrels.
2 elevating bars for mortar.
2 rear eccentric axle bars.
2 maneuvering bars.
1 friction clamp bar, long.
11 baskets for mortar implements.
1 dredging box.
6 iron sponge buckets.
4 wooden sponge buckets.

8	iron tar buckets.
35	water buckets.
37	watering buckets.
2	breech sights, 1.65-inch Hotchkiss gun.
4	breech sights, 4.5-inch siege guns.
2	breech sights, 8-inch howitzer.
100	faking boxes.
1	fuse auger.
4	fuse blocks.
1	fuse cutter.
6	fuse gouges.
11	fuse mallets.
9	fuse-plug wrenches.
6	fuse saws.
25	gunners' gimlets.
20	gunners' haversacks.
14	gunners' pincers.
16	gunners' pouches.
3	gunners' quadrants.
1	gun sight and elevating device, Zalinski's.
26	pairs gunners' sleeves.
16	handspikes, Gatling gun.
94	maneuvering handspikes.
55	trail handspikes.
8	handspikes, truck, iron, for barbette carriages.
114	harness sacks or bags.
5	sets harness, 1 horse, for Hotchkiss mountain gun.
24	sets harness, for 2 lead horses.
31	sets harness, for 2 wheel horses.
6	sets harness, for Laidley cavalry forge.
15	tow hooks.
1	interpolator, for pointing mortars, Paddock's.
7	common lanterns.
4	dark lanterns.
15	globe lanterns.
52	lanyards.
2	gunners' levels.
5	muzzle sights, for 12-pounder mountain howitzer.
3	muzzle or front sights.
5	pass boxes, 10-inch.
17	paulins, 5 by 5 feet.
5	paulins, 6 by 10 feet.
45	paulins, 8 by 10 feet.
136	paulins, 12 by 15 feet.
10	pendulum hausses, 3-inch.
2	pendulum hausses, 12-pounder.
5	pendulum hausse seats, for 12-pounder mountain howitzer
31	plummets.
12	pointing cords.
9	pouches, for pendulum hausse.
7	sight pouches.
43	priming wires, for field guns.
20	priming wires, for siege guns.
13	prolonges.
3	quoins.
16	rammer props, 8-inch converted rifled gun.

7 rammers and staves, 4.5-inch gun.
16 rammers and staves, 8-inch converted rifled gun.
6 scrapers for guns.
16 shell hooks, 8-inch converted rifled gun.
4 front sights, 8-inch rifle.
5 rear sights, 8-inch rifle.
4 rear sights, new pattern.
36 sponge covers, 3-inch rifled gun.
3 sponge covers, 4.5-inch.
17 sponge covers, 8-inch converted rifled gun.
5 sponge covers, light 12-pounder gun.
26 sponges and rammers, 3-inch rifled gun.
13 sponges and rammers, 6-pounder.
20 sponges and rammers, 12-pounder field gun.
17 sponges and rammers, 12-pounder mountain howitzer.
4 sponges and rammers, 8-inch siege howitzer.
7 sponges and staves, 4.5-inch gun.
17 sponges and staves, 8-inch converted rifled gun.
2 sponges and staves, 10-inch gun.
6 sponges and staves, 15-inch gun.
78 thumbstalls.
2 tompions.
11 tompions, 3-inch gun.
6 tompions, 12-pounder gun.
6 tompions, 4.5-inch gun.
10 tompions, 8-inch howitzer.
17 tompions, 10-inch.
3 tompions, 13-inch howitzer.
10 tompions, 15-inch.
46 tube pouches.
18 vent covers, field gun.
14 vent covers, 4.5-inch gun.
16 vent covers, 8-inch converted rifled gun.
2 vent covers, 8-inch howitzers.
30 vent pieces.
20 vent punches.
2 wiping rods.
8 worms and staves, field gun.
6 worms and staves, 15-inch.

IMPLEMENTS FOR GATLING GUN.

6 clamps for worm-gear.
6 drifts.
666 feed-cases.
7 gun covers.
4 headless shell extractors.
8 lock screw-drivers.
3 oscillators.
6 pin wrenches.
8 rear guide nut wrenches.
1 adjusting screw-driver.
7 small screw-drivers.
8 T screw-drivers.
8 adjusting screw-wrenches.
8 shell drivers.
6 wiping rods.

IMPLEMENTS FOR GARDNER GUN.

2 breech casing covers.
12 drifts.
2 extractors.
2 feed guides.
2 firing pins.
4 firing-pin springs.
2 hammers.
2 lock wrenches.
2 T screw-drivers.
2 shell drivers.
2 wiping rods.
2 sets of implements for Hotchkiss revolving gun.
1 cover for Hotchkiss revolving gun, caliber 1.50 inch.
8 sets of implements for Hotchkiss B. L. mountain gun, caliber 1.65 inch.

CLASSES IV AND V.

45 3-inch shot.
300 30-pounder shot.
224 4.5-inch shot.
50 8-inch shot.
50 15-inch shot.
2,300 1.65-inch Hotchkiss shell.
50 12-pounder shell.
25 3-inch shell.
247 4.5-inch shell.
100 24-pounder shell.
109 100-pounder shell.
500 8-inch shell.
525 10-inch shell.
20 13-inch shell.
75 15 inch shell.
125 3-inch case shot.
50 12-pounder canister.
1 5-pounder hand grenade.
3,000 shell and metallic cartridge cases, for breech-loading revolving gun, caliber 1.5 inch.

CLASS VI.

112 Hotchkiss magazine carbines.
1,103 Springfield carbines.
250 Sharps carbines, caliber .50
2,447 Springfield rifles.
400 Springfield rifles, "cadet."
63 Springfield rifles, long range.
10 Springfield rifles, officer's model.
1 Springfield rifle, caliber .50.
28 Parker's shot-guns.
228 Springfield shot-guns.
840 Colt's revolvers.
35 Schofield, Smith & Wesson revolvers.
10 cavalry officers' sabers.
44 light artillery sabers.

744 light cavalry sabers.
50 cadet swords.
38 musicians' swords.
35 N. C. O. swords.
5 staff and foot officers' swords.

CLASS VII.

2,735 saber belts.
2,777 saber belt plates.
93 carbine cartridge pouches.
12 carbine holsters and straps.
2,084 carbine slings.
1,537 carbine sling swivels.
121 pistol cartridge pouches.
2,475 pistol holsters.
1,059 saber knots.
155 saber attachments.
1,606 blanket bags.
7,038 clothing bags.
1,045 carbine sockets and straps.
10,800 cartridge belts.
45 waist belts.
2,843 waist belts and plates.
2,414 cartridge boxes.
692 carrying or shoulder braces.
8,599 canteens.
2,419 canteens and straps.
8,667 meat cans.
1,181 canteen corks and chains.
2,536 canteen covers.
10,122 tin cups.
7,694 forks.
65 sliding frogs.
2,442 haversacks.
6,176 haversacks and straps.
25 knapsacks (Hoffman's pattern).
7,262 knives.
46 waist belts and plates, N. C. O.
35 waist belt plates, cadet.
10,509 cartridge belt plates.
35 cap pouches.
1,984 steel bayonet scabbards.
75 intrenching tool scabbards.
210 trowel bayonet scabbards.
3,701 gun slings.
7,665 spoons.
631 great-coat straps.
605 blanket or coat straps.
1,619 pairs blanket bag shoulder straps.
50 brace yokes and stay straps, pattern 1872.
4,968 clothing bag straps.
9,892 canteen straps.
2,516 haversack straps.
42 stay straps.
62 valises.

APPENDAGES.

1,166	powder canisters, tin.
417	powder chargers, adjustable.
2,602	headless shell extractors.
1	powder flask.
162	bullet molds (4 balls).
1	shot pouch.
480	tumbler punches.
634	jointed ramrods.
655	wiping rods.
3,716	screw drivers.
119	spring vises.
251	brush wipers.
240	brushes and thongs.
4,580	nose bags.
2,145	saddle bags, leather.
192	saddle bags, canvas.
4,404	saddle blankets.
2,857	curb bridles.
1,369	watering bridles.
4,751	horse brushes.
1,034	hair cinchas or girths.
480	saddle cloths.
4,946	curry combs.
245	horse covers.
147	cruppers.
500	cruppers and back straps.
5	forage sacks.
853	girths.
4,463	halters.
4,425	halter straps.
6,255	lariats.
3,464	side lines.
881	links.
1,903	picket pins.
1,389	leather covered saddles.
420	Whitman tree saddles.
295	carbine sockets.
2,891	spurs.
3,736	spur straps.
320	spurs and straps, Mills'.
1,162	stirrups.
2,373	stirrup straps.
1,780	surcingles.

CLASS VIII.

7,000	Gatling gun cartridges, caliber 1 inch.
5,500	Gatling gun canister, caliber 1 inch.
656,020	carbine ball cartridges.
2,563,761	rifle ball cartridges.
60,000	rifle ball cartridges, caliber .50.
216,592	revolver ball cartridges.
150	revolver ball cartridges, caliber .44.
20,000	machine gun blank cartridges.
313,400	rifle blank cartridges.

3,000	rifle blank cartridges, caliber .50.
1,000	musket blank cartridges, caliber .58.
906,000	revolver blank cartridges.
500	rifle ball cartridges, caliber .44, "Winchester."
465,650	pounds round balls.
1,659,000	rifle bullets.
4,000	caps for shot-gun cartridges.
471,000	paper wads.
1,645,000	carbine cartridge wads.
2,853,750	cartridge primers.
6,050	blank cartridges, mountain howitzer.
5,467	blank cartridges, ½-pound charge.
730	blank cartridges, 1-pound charge.
22,091	blank cartridges, 3-inch gun.
4,494	blank cartridges, 6-pounder gun.
20,943	blank cartridges, 12-pounder gun.
2,020	assorted fuses.
27,389	pounds cannon powder.
600	pounds hexagonal powder.
500	pounds mammoth powder.
16,290	pounds mortar powder.
24,420	pounds musket powder.
1,100	electric primers.
148,280	friction primers.
15	pounds buck-shot.
11,400	pounds sporting shot, No. 8.

CLASS IX.

1	double block.
4	half blocks.
1	gin pole block.
4	quarter blocks.
1	single block.
1	treble block.
6	whole blocks.
1	set blocks for mounting 15-inch guns.
6	shot beds, wooden.
2,915	marksmen's buttons.
1	capstan and bar.
1	geared capstan or crab.
1	sling cart.
11	sling chains.
13	gun chocks.
104	roller chocks.
72	wheel chocks.
1	cradle for moving heavy guns.
1	collar, 15-inch gun.
24	disks.
12	disk staves.
1	gin fall.
5	shot frames, iron.
1	garrison gin.
3	gin handspikes.
1	hydraulic jack.
19	ornaments, cap, cadet.
20	shifting planks.

2	platforms, siege carriage.
1	platform, 8-inch converted gun.
2	platforms, 4½-inch siege gun.
2	platforms, 8-inch howitzer.
1	platform, 4½-inch siege howitzer.
3	platforms, mortar.
42	long rollers.
8	short rollers.
20	trace ropes.
233	signal flags.
9	skids.
42	pieces skidding, iron.
1	sling for cannon rope.
1	stadium, company, brass.
1	stadium bag.
2	plane tables.
75	intrenching tools.
1, 453	centers for targets.
65	target frames, wood, 4 x 6, A.
83	target frames, wood, 6 x 6, B.
18	target frames, wood, 12 x 12, C.
52	shot marks, 4-inch.
42	shot marks, 6-inch.
51	shot marks, 12-inch.
25	shot mark staves.
3, 875, 750	target pasters.
237	streamers.
4	targets, cotton cloth.
300	targets, paper.
399	targets, paper, reduced size.
10, 377	paper targets, A.
4, 529	paper targets, B.
2, 137	paper targets, C.
200	paper targets, E.
200	paper targets, F.
200	paper targets, G.
89	Laidley revolving targets.
15	targets, truck, "Cushing's."

CLASS X TO II.

8	nave bands.
4	tire bands.
40	tire bolts.
20	bolts No. 1, "A."
1	brake handle, cavalry forge.
2	feet chain, No. 1.
2	feet chain, No. 2.
2	forks, limber.
3	sponge-hooks.
4	hounds.
2	bronze hubs, Laidley cavalry forge.
13	keys for ammunition chest.
25	stay-pin keys and chains.
4	pounds nails.
6	poles.
12	linchpins.

1	Brewer's silent ratchet for Laidley cavalry forge.
1	shaft for Laidley cavalry forge.
2	front handspike sockets, 15-inch carriage.
2	gun carriage stocks.
132	washers and nuts.
16	linch washers.
22	wheels, complete.
2	wheels for Hotchkiss mountain gun carriage.
3	pole yokes.
1	wind pipe for traveling forge.

Class X to III.

6	breechings.
21	artillery bridles.
665	brass plated buckles.
445	iron roller buckles.
22	collars.
8	girths for drivers' saddles.
145	halters.
145	halter hitching straps.
3	rammer heads, 6-pounder gun.
12	rammer heads, 3-inch.
6	rammer heads, mountain howitzer.
2	rammer heads, 4.5-inch.
6	sponge heads, 6-pounder gun.
18	sponge heads, 3-inch.
6	sponge heads, mountain howitzer.
6	sponge heads, 4.5-inch.
1	shaft saddle with arch for roller band.
1	shaft inside, Laidley cavalry forge.
1	shaft outside, Laidley cavalry forge.
124	cold shut links.
37	pole pads.
75	rosettes for artillery bridles.
12	seats for drivers' saddle trees.
19	woolen sponges, 6-pounder gun.
151	woolen sponges, 3-inch.
127	woolen sponges, 12-pounder.
24	woolen sponges, mountain howitzer.
8	woolen sponges, 4.5-inch.
6	woolen sponges, 100 pounder.
7	artillery stirrups.
3	artillery stirrup straps.
6	breast straps.
3	hame straps.
6	loin straps.
50	pole straps.
10	lead traces.
2	wheel traces.
155	artillery whips.

Class X to IV and V.

200	fuse plugs, brass, 15-inch.
75	sabots for 8-inch Butler shot.
11	screw plugs, 8-inch shot.
200	tin straps for 10-inch projectiles.
200	tin straps, 15-inch shells.

Class X to VI.

SPARE PARTS SPRINGFIELD RIFLE.

1 lower band.
36 upper bands.
18 band springs.
4 barrels.
490 bayonets.
42 bayonet clasps.
72 bayonet clasp screws.
20 breech block caps.
254 breech block cap screws.
1 breech screw.
230 bridles.
225 bridle screws.
16 butt plate screws.
8 cam latches.
340 cam latch springs.
810 ejector springs.
773 ejector spring spindles.
47 ejector studs.
381 extractors.
2,201 firing pins.
360 firing pin screws.
343 front sights.
283 front sight pins.
896 pistol grips.
7 guard bows.
2 guard bow nuts.
10 guard bow swivels.
57 guard bow swivel screws.
1 guard plate.
50 guard screws.
11 hammers.
40 hinge pins.
6 locks.
6 lock plates.
139 main springs.
32 main spring swivels.
10 main spring swivel rivets.
14 ramrods.
45 ramrod stops.
637 rear sights.
2,607 rear sights, buck-horn plates.
35 rear sight bases.
159 rear sight base screws.
32 rear sight base springs.
111 rear sight leaves.
740 rear sight slide gibs.
54 rear sight slide plates.
5,601 rear sight slide screws.
77 rear sight joint pins.
71 rear sight slides.
139 rear sight slide blocks.
47 rear sight slide springs.

6	rod-bayonet springs.
296	sears.
277	sear screws.
236	sear springs.
81	sear spring screws.
113	side screws.
6	side screw washers.
101	stocks (complete).
519	stocks (wood part).
58	tang screws.
3	thumb pieces.
9	tip screws.
3	tips for stocks.
10	triggers.
7	trigger screws.
154	tumblers.
241	tumblers (swiveled).
312	tumbler screws.

PARTS OF OFFICER'S RIFLE.

5	ramrods.
2	globe and peep sights.

PARTS OF NAVY RIFLE.

36	butt stocks, cadet.

PARTS OF SPRINGFIELD CARBINE.

23	bands.
5	band springs.
2	breech blocks.
25	breech block caps.
45	breech block cap screws.
40	bridles.
50	bridle screws.
5	cam latches.
107	cam latch springs.
100	cover spring screws.
100	cover stud pins.
139	ejector springs.
107	ejector spring spindles.
16	ejector studs.
25	extractors.
158	firing pins.
55	firing pin screws.
3	guard bows.
10	guard bow nuts.
3	guard plates.
10	guard screws.
5	hammers.
10	hinge pins.
3	lock plates.
30	mainsprings.
15	mainspring swivels.

20 mainspring swivel rivets.
67 sears.
70 sear screws.
51 sear springs.
10 sear spring screws.
24 side screws.
31 rear sights (complete.)
75 rear sights, buck-horn plates.
100 rear sight leaves.
4 rear sight slide screws.
20 rear sight slide springs.
20 rear sight slide spring rivets.
36 stocks (complete).
5 swivel bars.
5 swivel-bar rings.
22 tang screws.
16 triggers.
10 trigger screws.
5 thumb pieces.
72 tumblers.
68 tumbler screws.

PARTS HOTCHKISS CARBINE AND RIFLE.

6 buck-horn sights.
30 extractors.
6 firing pins.
30 firing pin screws.
30 trigger pins.
30 trigger-spring screws.
30 bolt lock springs.
30 cut-off springs.
6 magazine springs.
30 mainsprings.
6 cartridge stops.
30 cartridge stop pins.
273 stocks, wood part.
30 tips.
6 triggers.
12 trigger springs.
300 rear sights, complete (Navy rifle).

PARTS OF COLT'S REVOLVER.

134 back strap screws.
40 bolts.
15 bolt screws.
35 center pins.
47 center pin bushings.
75 center pin catch screws.
23 center-pin screws.
32 ejector heads.
20 ejector rods.
99 ejector springs.
29 ejector tubes.
84 ejector tube screws.
45 firing pins.

65 firing pin rivets.
20 front sights.
10 gates.
10 gate catches.
60 gate catch screws.
149 gate springs.
109 guard screws, long.
92 guard screws, short.
119 hammers.
30 hammer cams.
30 hammer rolls.
30 hammer roll rivets.
72 hammer screws.
25 hands.
80 hand springs.
101 mainsprings.
85 mainspring screws.
74 sear springs.
10 sear spring screws.
64 sear and stop bolt screws.
77 sear and stop bolt springs.
57 sear and stop bolt spring screws.
53 stocks.
40 triggers.
65 trigger screws.

PARTS SCHOFIELD, SMITH & WESSON REVOLVER.

50 barrel catches.
52 base pins.
50 cylinder catches.
50 cylinder catch screws.
20 extractors.
70 extractor springs.
20 extractor stems.
20 hammers.
3 hand springs.
2 stocks.
6 triggers.

PARTS OF DOUBLE-BARREL, BREECH-LOADING SHOT-GUN.

100 firing pins.
100 firing-pin springs.
40 plungers.
40 plunger springs.
80 tumblers.
40 tumbler screws.

PARTS OF SWORDS.

10 browned scabbards, officers'.
6 scabbards, cadet.
30 steel scabbards, N. C. O.
36 steel scabbards, musicians'.
4 leather scabbards, N. C. O.

Class X to VII.

12,654	brass bar buckles.
2,230	brass wire buckles.
1,816	iron bar buckles.
220	iron horseshoe buckles.
1,858	iron roller buckles.
32	curb bits.
84	curb chains.
100	girth billets.
154	halter chains.
3,636	brass "D's" for cartridge belts.
252	side line fasteners.
8	bayonet scabbard frogs, hook attachment.
80	bridle headstalls.
468	halter bolts.
842	halters.
2,253	double hooks, brass wire.
3,723	double spring hooks for lariats.
200	curb strap loops.
3,153	ovals.
72	reins.
4,193	brass rings.
1,338	halter rings.
1,972	iron rings.
1,045	swivel rings for halters.
30	curb chain safes.
24	shields.
23	gross escutcheon screw pins, brass.
212	snaps for links.
24	snaps for side lines.
1,000	carbine sling swivel springs.
144	halter squares.
1,354	brass foot staples.
3,730	brass staples for rings.
2,232	wooden stirrups, with hoods.
2	stirrups with guidon socket.
260	cincha straps.
360	coat straps.
20	coupling straps, infantry equipments.
765	curb straps.
3,869	halter straps.
106	haversack straps.
20	hook straps.
40	safety straps for leather saddle-bags.
300	saddle-bag studs.
60	sweat leathers.
2,829	yards linen webbing, 4 inches wide.
48	yards girth webbing, 4½ inches wide.
72	yards linen webbing, 7½ inches wide.

Class X to VIII.

1,600	cartridge bags, ½-pound charge.
1,200	cartridge bags, 1-pound charge.
1,500	cartridge bags, 2-pounds charge.

2,780	cartridge bags, 6-pounder gun.
11,710	cartridge bags, 12-pounder gun.
6,065	cartridge bags, mountain howitzer.
1,000	cartridge bags, 20-pounder Parrott.
200	cartridge bags, 42-pounder gun.
800	cartridge bags, 100-pounder Parrott.
3,275	cartridge bags, 3-inch gun.
1,775	cartridge bags, 4.5-inch gun.
600	cartridge bags, 8-inch converted rifle.
2,300	cartridge bags, 10-inch gun.
50	cartridge bags, 15-inch gun.
50	fuse plugs, wood, 8-inch mortar.
520	fuse plugs, wood, 10-inch mortar.
500	fuse plugs, wood, 8-inch shell.
200	fuse-plug caps.
11,400	cartridge shells.

CLASS X TO IX.

1	capstan bar.
4	capstan pins, iron.
24	fencing bayonets.
18	stocks for fencing muskets.

PART SECOND: CLOTH, ROPE, THREAD, ETC.

4,749¼	yards cotton cloth.
30	pounds rocket cord.
190⅜	pounds sash cord.
34	pounds waste cotton.
3	yards red flannel.
200	pounds ixtle.
23	pounds marline.
103½	yards cartridge-bag material.
943½	pounds rope, hemp, and manila.
51	yards red serge.
148	pounds assorted thread.
158	pounds linen thread.
42½	pounds saddlers' thread.
645	pounds shoe thread.
15	pounds tow.
158¾	pounds twine.

IRONMONGERY.

25	pounds iron bolts.
20	papers iron brads.
10	pounds iron brads.
24	pounds sheet brass.
4	pounds copper burs.
24	pairs brass butts.
36	pairs iron butts.
30	feet card clothing.
1,000	pressure discs.
1,779	pounds band iron.
715	pounds bar iron.
55	pounds hoop iron.

105	pounds galvanized sheet iron.
5	pounds copper nails.
1,120	pounds horseshoe nails.
2,695	pounds iron nails.
360	saddle nails, japanned.
218	padlocks.
30	gross escutcheon pins.
$5\frac{5}{8}$	pounds escutcheon pins.
149	pounds assorted rivets and burrs.
178	pounds brass rivets and burrs.
722	pounds copper rivets and burrs.
73	pounds iron rivets and burrs.
$218\frac{1}{2}$	gross brass screws.
85	gross iron screws.
7,295	horseshoes.
4,981	pounds horseshoes.
$48\frac{1}{16}$	pounds solder.
200	pounds spikes.
352	pounds bar steel.
9	pounds spring steel.
91	papers copper tacks.
$42\frac{1}{2}$	pounds copper tacks.
10,000	copper tacks.
487	papers iron tacks.
467,000	iron tacks.
31	pounds iron tacks.
50	sheets tin.
137	pounds cast-iron truck wheels for targets.
71	pounds sheet zinc.

LEATHER, ETC.

983	sides bridle leather.
$23,406\frac{1}{2}$	pounds harness leather.
72	chamois skins.
$334\frac{3}{4}$	pounds black wax.
$4\frac{3}{4}$	pounds bristles.

LUMBER, ETC.

5,266	feet boards.
1,634	feet plank.
228	feet scantling.
509	feet timber.

HEATING, LIGHTING, ETC.

89	bath-bricks.
8,000	pounds bituminous coal.
113	pounds sperm candles.
1	stove.
12	lamp wicks.
$31\frac{1}{4}$	pounds lamp wicking.
43	quires crocus cloth.
2	quarts browning mixture.
688	quires emery cloth.
5	pounds emery.

29	quires emery paper.
12	pounds polishing material for leather.
478	pounds rotten stone.
79	quires sand paper.
12½	pounds scouring material.
643	papers tripoli.
8	button brushes.
3	wire scratch brushes.
4	button sticks.
118	boxes cleaning material, complete.
224	boxes ingredients for 2 quarts blacking.
3	feather dusters.
22	cleaning plates.
135	pounds bar soap.
2,827½	pounds castile soap.
139	pounds sponge.
214¾	pounds beeswax.

MATERIALS FOR OFFICE USE.

31	instruction books.
2	spring divers.
3	seal stamps.
51	pounds drawing paper.
3	pounds sealing wax.

LABORATORY STORES.

562	pounds laboratory paper, assorted.
50	pounds log paper.
15	pounds manila paper.
1,334	pounds packing paper.
10	pounds stencil paper.
2	glass bottles.
1	dynamometer.
1	opisometer.
5	gallons carbolic acid.
148½	gallons alcohol.
10	pounds borax.
70	pounds camphor.
100	pounds pulverized charcoal.
50	pounds ammoniated copper.
25	pounds sulphate of copper.
1	barrel rye flour.
100	pounds gum arabic.
55	pounds common glue.
100	pounds white glue.
1,912	pounds lubricant.
12	pounds concentrated lye.
1,000	pounds refined niter.
25	pounds ground pepper.
5	pounds red pepper.
244	pounds chlorate of potash.
4	pounds spermaceti.
10	pounds steel filings.
122	pounds nitrate of strontia.

300	pounds pulverized sulphur.
225	pounds tallow.
20	pounds tobacco.
5	pounds Japan wax.
44½	gallons whisky.

PAINTS, OILS, ETC.

2½	gallons benzine.
5	pounds white chalk.
597	gallons coal tar.
74	gallons Japan drier.
34	pounds patent drier.
26	gallons lacker.
71	pounds lampblack.
625	pounds red lead.
1,935	pounds white lead.
14	pounds extract logwood.
10	pounds yellow ocher.
7	quarts cosmoline oil.
4,356	pounds harness oil.
252	gallons kerosene oil.
12	gallons lard oil.
$900\frac{37}{120}$	gallons linseed oil.
1	gallon lubricating oil.
95½	gallons neat's-foot oil.
40	gallons neutral oil.
1	gallon olive oil.
615	gallons sperm oil.
1,399	pounds black paint.
10	pounds chrome-green paint.
4	pounds ivory-black paint.
450	pounds lead-color paint.
4,925	pounds metallic paint.
2,870	pounds olive paint.
1	pound Prussian-blue paint.
90	pounds red paint.
65	pounds putty.
10	pounds rosin.
10	pounds shellac.
566½	gallons turpentine.
19	pounds umber.
25	gallons black asphalt varnish.
22	gallons copal varnish.
3	gallons damar varnish.
10	gallons Japan varnish.
2	pounds vermilion.
34¼	pounds whiting.

MISCELLANEOUS ARTICLES.

1	box for sets reloading tools.
16	Madigan ammunition chests.
280	arm chests.
121	arm racks.
12	metallic powder barrels.

852 wooden powder barrels.
31 tin cans.
3 forge chests.
1 instrument case.
228 field cases.
21 chamois-skin sword cases.
10 pounds flax packing.
8 cans axle grease.
530 pounds wheel grease.
70 metallic powder kegs.
10 feet rubber packing.
3 pounds tarred paper.
1 spring wagon.

INSPECTING INSTRUMENTS.

2 pressure gauges.
1 ring gauge, 3-inch rifle.
1 ring gauge, 4.2-inch rifle.
1 ring gauge, 4.5-inch rifle.
2 ring gauges, 8-inch rifle.
1 star gauge.
1 star gauge with rests and sets of points.
1 caliper for thickness of walls of rifle projectile.
2 scales for measuring pressure cut.

RELOADING TOOLS.

223 sets tools for reloading cartridges.
4 crimping dies.
3 reloading dies.
4 resizing dies.
236 drifts.
291 extractor hooks and pins.
252 extractor levers.
274 extractor lever screws.
40 extractor primers.
23 extractors and recappers.
229 funnels.
324 ladles.
9 mallets.
283 priming tools.
608 pins for primer extractors.
2 primer punches.
12 reloading punches.
15 resizing punches.
3 reloading tools.
22 shell scrapers.
2 safety sockets.
4 tin strainers.
6 teeth for Winchester reloader.
3 brush wipers.

TOOLS, ETC.

1 adze.
4 anvils.
15 aprons, leather.

4 awls, brad.
722 awls, saddlers'.
10 awls, peg, with patent handles.
17 awls, stub, handled.
13 awls, seat, handled.
89 awl handles.
21 awl handles, patent.
23 axes, felling.
3 axes, hand.
37 ax handles.
4 augers.
43 auger bits.
1 shoeing box.
2 bill hooks.
377 corn brooms.
1 split broom.
6 assorted brushes.
10 brushes, dusting.
289 brushes, paint.
189 brushes, sash.
22 brushes, stencil.
40 bits for brace.
2 hand braces.
16 chalk lines.
3 channelers.
14 chisels, firmer.
3 chisels, cold iron, hand.
2 chisels, hot iron, hand.
10 chisel handles.
8 claw tools.
36 compasses.
2 countersinks.
24 creasers.
20 saddlers' clamps.
1 divider.
5 dies and taps.
7 dies, ½ to 1½ inch.
3 die stocks.
1 drill stock.
17 drills, various.
76 edge tools.
196 files.
10 formers for rockets.
4 gauges.
29 gimlets.
8 gouges.
4 grindstones.
4 grindstone arbors and cranks.
3 grindstone stands.
2 claw hammers.
27 hand hammers.
20 riveting hammers.
14 saddlers' hammers.
2 shoeing hammers.
4 sledge hammers.
1 hand barrow.

17	hatches.
4	heading tools.
1	jackscrew.
6	gauge knives, draw.
56	half-round knives.
31	head knives.
45	shoe knives.
26	shoeing knives.
7	splitting knives.
1	spirit level.
15	mallets.
1	tape measure.
4	collar needles.
5,420	saddlers' needles.
4	nail extractors.
39	cutting nippers.
2	oil cans.
12	oil droppers.
31	oil stones.
8	pickaxes.
10	pickaxe handles.
6	pincers.
4	planes.
10	plane irons.
14	pliers.
1	glue pot.
17	pricking carriages.
46	pricking wheels.
2	pritchels.
24	hand punches.
16	saddlers' punches.
38	spring punches.
14	punching blocks.
3	rakes.
140	rasps.
4	reaping hooks.
2	rounding irons.
33	rules, 2-foot.
30	sandstones.
10	saws.
3	saw blades,
1	counter scales and weights.
18	scissors.
9	copper scoops.
22	screw drivers.
2	scythes.
2	scythe-sneaths.
7	scythe stones.
8	rivet-sets.
26	shears.
1	copper shovel.
12	shovels, long-handled.
16	slickers.
69	slippers, magazine.
10	spades.
3	spoke shaves.

2	trying squares.
1	stamp, letters and figures.
5	stencil plates, letters and figures.
6	ticklers.
12	thimbles.
12	tool bags for saddlers' and smiths' tools.
7	tongs.
2	tubes for spring punches.
5	vises.
8	wrenches.

APPENDIX 4.

Apportionment of ordnance, ordnance stores, &c., for the fiscal year ended June 30, 1882, under sections 1661 *and* 1667 *Revised Statutes United States, and regulations established in conformity therewith.*

States and Territories.	Number of Senators and Representatives.	Money-value.
Alabama	10	$4,797 85
Arkansas	6	2,878 71
California	6	2,878 71
Colorado	3	1,439 36
Connecticut	6	2,878 71
Delaware	3	1,439 36
Florida	4	1,919 14
Georgia	11	5,277 64
Illinois	21	10,075 49
Indiana	15	7,196 78
Iowa	11	5,277 64
Kansas	5	2,398 93
Kentucky	12	5,757 42
Louisiana	8	3,838 28
Maine	7	3,358 50
Maryland	8	3,838 28
Massachusetts	13	6,237 21
Michigan	11	5,277 64
Minnesota	5	2,398 93
Mississippi	8	3,838 28
Missouri	15	7,196 78
Nebraska	3	1,439 36
Nevada	3	1,439 36
New Hampshire	5	2,398 93
New Jersey	9	4,318 06
New York	35	16,792 48
North Carolina	10	4,797 85
Ohio	22	10,555 27
Oregon	3	1,439 36
Pennsylvania	29	13,913 76
Rhode Island	4	1,919 14
South Carolina	7	3,358 50
Tennessee	12	5,757 42
Texas	8	3,838 28
Vermont	5	2,398 93
Virginia	11	5,277 64
West Virginia	5	2,398 93
Wisconsin	10	4,797 85
Arizona Territory*	3	1,439 36
Dakota Territory*	3	1,439 36
Idaho Territory*	3	1,439 36
New Mexico Territory*	3	1,439 36
Montana Territory*	3	1,439 36
Utah Territory*	3	1,439 36
Washington Territory*	3	1,439 36
Wyoming Territory*	3	1,439 36
District of Columbia*	3	1,439 36
Total	396	189,995 00
Freights, &c.	......	10,005 00
		200,000 00

* Apportionment according to the first paragraph of the President's regulation of April 30, 1855.

APPENDIX 5.

Statement of ordnance, ordnance stores, &c., distributed to the militia from July* 1, 1881, *to June* 30, 1882, *under sections* 1661 *and* 1667 *Revised Statutes United States.

CLASS I.

2 10-pounder Parrott guns.
2 6-pounder bronze guns.
1 3-inch wrought-iron rifled gun, model 1861.
6 Gatling guns, 10 barrels, long, caliber .45.

CLASS II.

2 carriages and limbers for 10-pounder guns.
2 carriages and limbers for 6-pounder guns.
1 carriage and limber for 3-inch gun.
6 carriages and limbers for Gatling guns, caliber .45.
2 caissons and limbers for 10-pounder guns.

CLASS III.

300 feed cases.
11 gunners' haversacks.
4 gunners' gimlets.
3 gunners' pincers.
11 handspikes, trail.
10 lanyards for friction primers.
10 priming wires.
5 prolonges.
6 tube pouches.
12 thumb-stalls.
5 paulins, 12 by 15 feet.
6 vent covers.
1 pendulum hausse.
1 pendulum hausse pouch.
1 pendulum hausse seat
6 sets of artillery harness, 2 horses, wheel.
2 sets of artillery harness, 2 horses, lead.
3 sponge buckets, iron.
3 tar buckets, iron.
4 vent punches.
3 gunners' pouches.
1 sponge and rammer, 12-pounder gun.
6 sponges and rammers, 6-pounder gun.
20 sponges and rammers, 3-inch gun.
4 sponge covers, 6-pounder gun.
4 sponge covers, 3-inch gun.
3 worms and staves, 12-pounder gun.
1 worm and stave, 3-inch gun.

CLASS V.

150	12-pounder shot, fixed.
100	3-inch shot, fully prepared.
144	12-pounder canister, fixed.
80	10-pounder canister, 3-inch, fixed.
60	10-pounder canister, 2.9 bore, fixed.

CLASS VI.

3,696	Springfield rifles, caliber .45.
700	Springfield carbines, caliber .45.
300	Sharps' carbines, caliber .50.
1,662	Colt's revolvers, caliber .45.
100	Schofield's Smith & Wesson revolvers, caliber .45.
84	officers' swords.
165	non-commissioned officers' swords.
420	light cavalry sabers.
147	light artillery sabers.
37	bayonets.

CLASS VII.

975	knapsacks and straps.
7,188	waist belts and plates.
11,049	cartridge boxes.
9,544	steel bayonet scabbards.
7	non commissioned officers' sword belts and plates.
496	saber belts and plates.
10	non commissioned officers' shoulder belts and plates.
300	carbine slings.
300	carbine-sling swivels.
200	carbine cartridge pouches.
5,073	gun slings.
3,200	canteens and straps.
3,200	haversacks and straps.
2,000	blanket bags and straps.
50	blanket bags.
100	coat straps.
100	shoulder straps.
10	scabbards, non-commissioned officers' swords.
216	saddle blankets, gray.
3	saddle cloths, felt.
9	saddle cloths, canvas.
9	pairs spurs and straps.
1,000	meat cans.
1,000	tin cups.
1,000	knives.
1,000	forks.
1,000	spoons.
145	pistol holsters.
194	saddles.
186	bridles.
7	whips.
9	curry combs.
9	horse brushes.

CLASS VIII.

100 blank cartridges for 12-pounder gun.
200 blank cartridges for 6-pounder gun.
950 blank cartridges for 3 inch gun.
65,000 rifle blank cartridges, caliber .50.
85,000 rifle blank cartridges, caliber .45.
433,200 rifle ball cartridges, caliber .50.
1,181,500 rifle ball cartridges, caliber .45.
1,000 carbine blank cartridges.
21,000 carbine ball cartridges.
34,500 revolver ball cartridges.
2,500 lubricated bullets (405 grains).
400,000 lubricated bullets, caliber .50.
15,000 lubricated bullets, caliber .45.
30 pounds musket powder.
13,180 friction primers.
418,000 cartridge primers.
40,000 cartridge shells, caliber .50.
1,500 cartridge shells, caliber .45.

CLASS X.

2 pole pads.
1 pole yoke.
1 pair pole straps.

SPARE PARTS FOR SPRINGFIELD RIFLES, CALIBER .50.

50 stocks.
450 ejector springs.
450 ejector spring spindles.
200 extractors.
50 bridles.
50 bridle screws.
25 breech blocks.
50 breech screws.
50 band springs.
130 bayonet clasps.
200 bayonet clasp screws.
100 butt plate screws.
25 cam latches.
300 cam latch springs.
200 firing pins.
100 firing pin screws.
50 guard plates.
50 guard plate bows.
100 guard screws.
50 guard bow swivels.
200 guard bow swivel screws.
100 guard bow nuts.
50 hinge pins.
50 hammers.
100 leaf slides.
200 mainspring swivels.
50 locks.
50 lower bands.

50	ramrods.
400	rear sights,
50	rear sight springs.
100	rear sight base screws.
100	sears.
25	sear springs.
200	sear spring screws.
100	side screws.
100	side screw washers.
100	tumblers.
100	tumbler screws.
10	tips.
25	tip screws.
100	trigger screws.
50	tang screws.
50	upper bands.
50	upper band swivels.
250	upper band swivel screws.

SPARE PARTS FOR SPRINGFIELD RIFLES, CALIBER .45.

1	barrel.
1	butt plate.
8	butt plate screws.
2	butt plate pins.
62	breech blocks.
3	breech block caps.
22	breech screws.
63	bayonet clasps.
63	bayonet clasp screws.
15	bayonet clasp stops.
54	bridles.
70	bridle screws.
6	band springs.
123	cam latches.
15	cam latch springs.
3	extractors.
45	ejector springs.
3	ejector spring spindles.
102	ejector studs.
178	firing pins.
58	firing pin screws.
1,104	front sights.
6	front sight pins.
1,000	front sight rivets.
1	guard plate.
1	guard bow.
10	guard bow nuts.
60	guard screws.
110	guard bow swivels.
100	guard bow swivel screws.
15	guard bow swivel rivets.
1	guard.
110	hammers.
5	lower bands.
1	lock plate.

103 hinge pins.
20 mainsprings.
103 mainspring swivels.
110 mainspring swivel rivets.
151 rear sights.
10 rear sight leaves.
20 rear sight joint pins.
10 rear-sight bases.
120 rear-sight base screws, slotted.
15 rear-sight base springs.
76 ramrods.
202 ramrod stops.
11 stocks.
57 sears.
70 sear screws.
20 sear springs.
20 sear-spring screws.
110 side-screw washers.
12 stay pins.
180 side screws.
54 triggers.
4 trigger screws.
102 tips.
254 tip screws.
200 tumblers.
62 tumblers, swiveled.
20 tumbler screws.
60 tang screws.
110 upper bands.
4 screw-drivers, model 1879.
4 headless shell extractors.
6 linchpins.

MISCELLANEOUS.

83 sets reloading tools.
1 box cleaning material.
10 boxes leather polish.
1 scratch brush.

APPENDIX 6.

Statement of ordnance, ordnance stores, &c., distributed to the Territories, and States bordering thereon, from July 1, 1881, *to June* 30, 1882, *under the joint resolutions of July* 3, 1876, *March* 3, 1877, *and June* 7, 1878, *and the act of May* 16, 1878.

1,400	Springfield rifles, caliber .50.
1,000	Sharps carbines, caliber .50.
1,600	cartridge boxes.
1,100	leather bayonet scabbards.
1,800	waist belts and plates.
1,000	gun slings.
1,000	carbine slings and swivels.
105,000	rifle ball cartridges, caliber .50.
15,000	carbine ball cartridges, caliber .50.

APPENDIX 7.

Statement of ordnance, ordnance stores, &c., distributed to colleges and universities from July 1, 1881, *to June* 30, 1882, *under section* 1225 *Revised Statutes United States, as amended by act approved July* 5, 1876.

CLASS I.

4 3-inch wrought-iron rifled guns, model 1861.

CLASS II.

4 carriages and limbers for 3-inch guns.
2 caissons and limbers for 3-inch guns.

CLASS III.

10 gunners' haversacks.
10 handspikes, trail.
20 lanyards.
10 priming wires.
20 thumbstalls.
10 tube pouches.
10 vent covers.
4 paulins, 12 by 15 feet.
1 pendulum hausse.
1 pendulum hausse seat.
1 pendulum hausse pouch.
4 tompions.
12 sponges and rammers for 6-pounder gun.
8 sponges and rammers for 3-inch rifled gun.
12 sponge covers for 6-pounder gun.
8 sponge covers for 3-inch rifled gun.

CLASS VI.

450 Springfield rifles, cadet, caliber .45.
20 non-commissioned officers' swords.

CLASS VII.

450 cartridge boxes.
450 steel bayonet scabbards.
20 shoulder belts and plates.
450 waist belts and plates.

CLASS VIII.

200 blank cartridges for 12-pounder gun.
600 blank cartridges for 6-pounder gun.
1,000 blank cartridges for 3-inch gun.
9,500 carbine blank cartridges, caliber .50.
12,000 carbine blank cartridges, caliber .45.
9,500 carbine ball cartridges, caliber .50.
11,000 carbine ball cartridges, caliber .45.
1,000 rifle blank cartridges, caliber .45.
5,400 friction primers.

APPENDIX 8.

Statement of ordnance stores issued to the Executive Departments during the year ended June 30, 1882, *under the provisions of the act of March* 3, 1879.

TO THE TREASURY DEPARTMENT.

6	Springfield carbines.
1,200	carbine ball cartridges.

TO THE POST-OFFICE DEPARTMENT.

100	Springfield rifles.
1,000	rifle ball cartridges.

APPENDIX 9.

Report of action taken under the act of March 3, 1881, during the fiscal year ended June 30, 1882.

SOLD.

To E. I. Du Pont de Nemours & Co.

1881.				
July	6.	77,700	pounds serviceable cannon powder, at 12 cents per pound	$9,324 00
	7.	100,000	pounds serviceable musket powder, at 14 cents per pound	14,000 00
	13.	10,000	pounds unserviceable musket and rifle powder, at 8 cents per pound	800 00
	13.	1,200	pounds unserviceable cannon powder, at 8 cents per pound	96 00
Aug.	25.	7,600	pounds serviceable cannon powder from broken-up ammunition at 10 cents per pound	760 00
	25.	2,800	pounds damaged mortar powder, at 5 cents per pound	140 00
Nov.	14.	192,400	pounds cannon powder, at 10½ cents per pound	20,202 00

To Laflin & Rand Powder Company.

July	8.	13,200	pounds cannon powder, at 12 cents per pound	1,584 00
Aug.	31.	80,100	pounds cannon powder, at 12 cents per pound	9,612 00
Oct.	21.	51,400	pounds cannon powder, at 10½ cents per pound	5,397 00
Dec.	1.	103,800	pounds cannon powder, at 10½ cents per pound	10,899 00

To Oriental Powder Company.

July	12.	43,800	pounds cannon powder, at 12 cents per pound	5,256 00
Aug.	26.	14,900	pounds cannon powder, at 10½ cents per pound	1,564 50
	29.	17,500	pounds cannon powder, at 10½ cents per pound	1,837 50

To W. James Whaley.

July	1.	50	3-inch Parrott shot, at 25 cents each	12 50
	7.	50	3-inch Parrott shot, at 25 cents each	12 50

To F. W. Dawson.

July	18.	50	2.9-inch Parrott case shot, at 25 cents each	12 50
Oct.	13.	50	2.9-inch Parrott case shot, at 25 cents each	12 50

To L. Frank.

Aug.	27.	8,693	3-inch Hotchkiss case shot, 34$\frac{1307}{2240}$ tons, at $31.15 per ton	1,705 89

To A. J. Simpson.

Sept.	6.	84	3-inch Dyer case shot, $\frac{840}{2240}$ tons, at $24.55 per ton		9 20
		1,439	3-inch Dyer canister, 6$\frac{950}{2240}$ tons, at $62 per ton		398 39
Oct.	31.	3,641	3-inch Dyer shells	14$\frac{1653}{2240}$ tons, at $23.15 per ton	341 19
		28 32	pounds Dyer shells		
Nov.	9.	6,315	3-inch Hotchkiss canister,	20$\frac{753}{2240}$ tons, at $15.35 per ton	312 16
	9.	87	3.67-inch Hotchkiss canister,		
	9.	84	3.80-inch Hotchkiss canister,		
	9.	503	3-inch Schenkl shells, 1$\frac{2036}{2240}$ tons, at $16.15 per ton		30 83
	9.	290	3-inch Schenkl case shot, 1$\frac{805}{2240}$ tons, at $22.55 per ton		30 66
	9.	160	20-pounder Schenkl case shot, 1$\frac{960}{2240}$ tons, at $22.55 per ton		32 21
	9.	305	20-pounder Parrott shells,	3$\frac{348}{2240}$ tons, at $16.15 per ton	50 96
	9.	60	20-pounder Parrott case shot,		
	9.	18	3.8 inch Parrott shells,		
	9.	8	3.67-inch Parrott shot,		
	9.	15	3.8-inch Hotchkiss canister,		

To F. Bannerman.

Oct.	6.	6,120	12-pounder case shot, at 14½ cents each	887	40
	6.	378	24-pounder Parrott shot, at 34 cents each	128	52
	6.	1,649	24-pounder Parrott shell, at 30 cents each	494	70
	6.	327	24-pounder Parrott case shot, at 30 cents each	98	10
	6.	520	32-pounder Parrott shot, at 40 cents each	208	00
	6.	1,067	32-pounder Parrott shells, at 40 cents each	426	80
	6.	376	42-pounder Parrott shot, at 52¾ cents each	198	34
	6.	375	42-pounder Parrott shells, at 51¼ cents each	192	19
	6.	6	3.67-inch Hotchkiss shells, at 11½ cents each		69
	6.	1,068	3 8-inch Hotchkiss shells, at 14½ cents each	154	86
	6.	4	3.67-inch Hotchkiss case shot, at 18 cents each		72
	6.	289	3.67-inch Hotchkiss shot, at 5¾ cents each	16	62
	6.	450	3-inch Dyer shot, at 7½ cents each	33	75
	6.	530	3-inch Dyer case shot, at 5¾ cents each	30	48
	17.	1	3-inch Hotchkiss shot		10
	17.	19,258	3-inch Hotchkiss case shot, at 11 cents each	2,118	38
	17.	20	3.67-inch Hotchkiss case shot, at 18 cents each	3	60
	17.	4,152	3-inch Parrott shot, at 6 cents each	249	12
	17.	4,572	3-inch Parrott shells, at 6 cents each	274	32
	17.	430	3-inch Parrott case shot, at 10 cents each	43	00
	17.	320	3-inch Parrott case shot, at 9 cents each	28	80
	17.	2	20-pounder Parrott shot, at 12½ cents each		25
	17.	2,837	20-pounder Parrott shells, at 10½ cents each	297	89
	17.	378	20-pounder Parrott shells, at 9¼ cents each	34	97
	17.	4,104	30-pounder Parrott shells, at 19 cents each	779	76
	17.	14,217	30-pounder Parrott shells, at 15¾ cents each	2,239	17
	17.	2,061	30-pounder Parrott case shot, at 33½ cents each	690	44
	17.	25	30-pounder Parrott case shot, at 32 cents each	8	00
	17.	1	32-pounder Parrott shot		40
	17.	50	32-pounder Parrott shells, at 40 cents each	20	00
	17.	50	42-pounder Parrott shot, at 51¼ cents each	25	63
Dec.	10.	407	6-pounder case shot, at 7 cents each	28	49
	10.	2,188	12-pounder case shot, at 14 cents each	306	32
	10.	273	3-inch Parrott case shot, at 10 cents each	27	30
	10.	4,970	30-pounder Parrott case shot, at 33½ cents each	1,664	95
	10.	2,184	20-pounder Parrott shells, at 10½ cents each	229	32
	10.	1,750	30-pounder Parrott shot, at 19 cents each	332	50
	10.	20,735	30-pounder Parrott shells, at 15 cents each	3,110	25
	10.	15	3-inch Dyer shells, at 5¼ cents each		79
	10.	22	3-inch Boekel shells, at 5¼ cents each	1	16
	10.	550	3-inch Armstrong shells, at 5¼ cents each	28	87
	17.	7,335	30-pounder Parrott shells, at 15 cents each	1,100	25
	17.		Freight from Washington Arsenal to New York Arsenal on 82 tons, at $2.80 per ton	229	60

To M. Lissberger.

Oct.	17.	64	3.67-inch Hotchkiss shells,	$133\frac{590}{2240}$ tons, at $23.85 per ton	3,178	33
	17.	2,690	4.5-inch Hotchkiss shot,			
	17.	8,030	4.5-inch Hotchkiss shells,			
	17.	315	3-inch Dyer shells,			
	17.	1,346	3-inch Dyer case shot,			
1882.						
Jan.	4.	187	42-pounder Parrott shot,	$16\frac{1037}{2240}$ tons, at $24.50 per ton	403	36
	4.	296	42-pounder Parrott shells,			

To J. Torrance.

1881.					
Oct.	17.	1,560	3-inch Hotchkiss shells, at 10¾ cents each	$167	70
	17.	35,513	12-pounder case shot, at 17⅛ cents each	6,081	60
	17.	3,174	24-pounder case shot, at 47⅛ cents each	1,495	75
	17.	478	32-pounder case shot, at 60⅛ cents each	287	40
	17.	27,506	3-inch Hotchkiss shell, at 10¾ cents each	2,956	89
	17.	55	3-inch Hotchkiss case shot, at 10¾ cents each	5	91

To Joseph A. Buck.

Nov. 23.	864	6-pounder shot, 12-pounder shot, 32-pounder shot, 8-inch shot, $231\frac{68}{2240}$ tons, at $20.05 per ton	4,632 16
23.	22,339		
23.	223		
23.	3,700		
23.	1,480	3-inch Hotchkiss case shot, $5\frac{1820}{2240}$ tons, at $30.05 per ton	174 67
23.	11,717	8-inch Columbiad shells, 8-inch mortar shells, $611\frac{1148}{2240}$ tons, at $15.12½ per ton	9,249 13
23.	18,083		
23.	30	2.9-inch Hotchkiss shells, 3-inch Hotchkiss shot, 3-inch Hotchkiss shells, 3.67-inch Hotchkiss shells, 4.5-inch Hotchkiss shot, 3.67-inch Hotchkiss shot, 3.8-inch Hotchkiss shells, 3.8-inch Hotchkiss shot, 24-pounder Hotchkiss shells, 30-pounder Hotchkiss case shot, $100\frac{55}{2240}$ tons, at $28.05 per ton	2,805 69
23.	750		
23.	22,729		
23.	234		
23.	725		
23.	5		
23.	106		
23.	100		
23.	24		
23.	8		
29.	9,390	8-inch shot, $270\frac{856}{2240}$ tons, at $19.05 per ton	5,150 78
29.	10,504	8-inch shells, $229\frac{1738}{2240}$ tons, at $14.12½ per ton	3,245 58

To Block, Pollock & Co.

1882.			
May 5.	2,892	24 pounder shot, at 15 cents each	433 80
5.	310	stands 24-pounder grapeshot, at 11 cents each	34 10
5.	861	32-pounder shot, at 21 cents each	180 81
5.	80	stands 32-pounder grapeshot, at 15 cents each	12 00
5.	49	32-pounder canister shot, at 10 cents each	4 90
5.	473	42-pounder shot, at 27 cents each	127 71
5.	38	stands 42-pounder grapeshot, at 15 cents each	5 70
5.	38	42-pounder canister shot, at 11 cents each	4 18

To E. L. Granger.

June 23.	50	2.9-inch Parrott case shot, at 25 cents each	12 50

To James Simons.

June 29.	50	2.9-inch Parrott case shot, at 25 cents each	12 50
		Total proceeds	141,211 35

PURCHASED.

From E. I. Du Pont de Nemours & Co.

1881.			
Aug. 5.	10,000	pounds musket powder, at 22 cents per pound	$2,200 00
Sept. 9.	700	pounds hexagonal powder, at 25 cents per pound	175 00
21.	15,000	pounds hexagonal powder, at $25\frac{4}{10}$ cents per pound	3,810 00
Oct. 1.	10,000	pounds musket powder, at 22 cents per pound	2,200 00
Nov. 18.	35,000	pounds hexagonal powder, at $25\frac{4}{10}$ cents per pound	8,890 00
Dec. 10.	20,000	pounds musket powder, at 22 cents per pound	4,400 00
Dec. 29.	1,000	pounds square powder, at 25 cents per pound	250 00
Dec. 29.	1,000	pounds hexagonal powder, at 25 cents per pound	250 00
1882.			
May 1.	20,000	pounds musket powder, at 22 cents per pound	4,400 00
Jan. 27.	10,000	pounds musket powder, at 22 cents per pound	2,200 00

From Ames Manufacturing Company.

June 14.	20	8-inch Eureka cored shot, 3,600 pounds, at 9½ cents per pound	342 00
		Total purchased	29,117 00

On April 7, 1882, a contract was made with the South Boston Iron Company for 2,000 8-inch Butler cored shot, at 8 cents per pound.

APPENDIX 10.

REPORT OF THE PRINCIPAL OPERATIONS AT THE ROCK ISLAND ARSENAL, ILLINOIS, DURING THE FISCAL YEAR ENDED JUNE 30, 1882.

LIEUT. COL. D. W. FLAGLER, ORDNANCE DEPARTMENT, COMMANDING.

[Four plates.]

SHOP G.

(An iron working and finishing shop for the arsenal.)

This shop has been completed during the year. The principal work done has been the plastering and painting; the iron stairways have all been built; a stone and concrete basement floor has been put in; the area walls and stone steps and platforms have been completed; the grading around the shop has been completed, and all the stone walks have been laid except the one on Fourth street, along the east side of the building.

This shop is built of the Grafton limestone from the quarries at Grafton, Ill., on the Mississippi River, just below the mouth of the Illinois River; and the Ste Genevieve quarries, in Missouri, about 140 miles south of Saint Louis.

The sandstone was used only for the entablature, water table, caps, and sills.

Both of these stones are believed to be of better quality and more durable than the stone in the other shops, and the walls are somewhat handsomer.

SHOP I.

(A wood-working and leather-working shop for the arsenal iron work.)

The iron beams for one-half of the second floor of this shop and all of the third floor have been purchased and fitted in the arsenal shops; the iron columns and iron caps and bases for the two stories have been cast and fitted up in the arsenal shops and all this iron work has been put up.

The iron beams for the roof frame were purchased during the year; all the bar iron for the roof was manufactured in the arsenal rolling-mill, and the whole roof frame manufactured in the arsenal shops and finished ready to put up.

The special report of first lieut. L. L. Bruff, Ordnance Department, who was in charge of the rolling-mill when this iron was manufactured, is appended hereto and marked Appendix A.

STONE WORK.

The remainder of the stone work required for the second and third stories has been purchased and cut, and the walls of one-half of the second, and all of the third stories have been built, completing the walls of the building. A portion of the area walls has been built and all the masonry for the exterior steps and platforms put in.

It is found that some of the limestone steps and platforms of the other shops have been injured by the action of the atmosphere, water, and frost in this severe climate, and by wear. On this account I have built the shops and platforms of this shop of granite. They add much to the appearance of the building, and are practically imperishable. The only objection to its use is the cost. The first cost of the stone is about double that of dimension limestone, and the cost of cutting about five times that of limestone.

OTHER WORK.

The window frames, sash, doors, and door frames for this shop have all been manufactured in the arsenal shops, and painted; the sewers have been put in, a portion of the brick for the fire-proof arches has been purchased, a good deal of grading has been done around the shop, and the whole of the court has been graded and paved.

SHOP H.

(An iron-finishing shop for the armory.)

The work done on this building during the fiscal year is as follows:

IRON WORK.

All the iron beams for the second floor have been purchased and fitted in the arsenal shops; the columns and iron caps and bases for the first story have been cast and fitted in the arsenal shops, and this iron work put up.

STONE WORK.

The stone for the second story has been purchased and cut, and the walls of this story built, and about one-half of the stone for the third story has been purchased and cut. About one-half of the area walls has been built. A portion of the lumber required for this building has also been purchased and stacked for seasoning.

SHOP K.

(A finishing and stocking shop for the armory.)

This shop was commenced in July, 1881. The work done on it during the fiscal year is as follows:

All the excavations for the basement story—about 9,800 cubic yards—have been made, and the material obtained therefrom used in grading about the building.

Excavations for foundations were made and foundations for about two-thirds of the main walls and two-thirds of the piers were put in during the fiscal year.

As the whole of the foundations have been completed before writing this report, I have prepared, and transmit herewith, a drawing showing all the foundations on one sheet. (See Plate 1.)

All the footing-stones for the main wall have been purchased, and two-thirds of them set, and 523 cubic yards of stone for the basement story purchased and cut.

The front area wall, containing 6,600 cubic feet of masonry, has been built, and a portion of the sewers for the building put in.

from two large saw-mills located on the Moline shore below the point where the coffer would have reached the shore; would have left their logs on the bottom of the pool, cut off the supply of logs, and compelled the mills to shut down for several months, probably from September 1, 1881, to April 1, 1882.

In consequence of protests from the mill companies I changed the proposed location of the coffer and ran it down nearly parallel to the Moline shore about 2,000 feet, and then into the shore below the mills at a point about 900 feet above the arsenal bridge to Moline. This made the total length of the coffer-dam about 3,500 feet, adding greatly to its cost and the difficulties of constructing it.

In the latter part of August the stage of water had fallen to 2.7 feet, and I commenced putting in the coffer. The river began to rise at once, but as high water at that season was almost unknown I supposed it was only a temporary rise, and kept on with the work, contending with many difficulties and incurring great expense.

On September 21 the stage had reached 7.5 feet, and I was compelled to stop work. The river continued rising until October 27, when it reached a stage of 17.7 feet, nearly the highest water ever known here. Before the work stopped I had completed 2,900 feet of the coffer. About one half of this was washed out by the freshet, and the work could not be resumed again during the fiscal year.

The total expenditures during the year on the coffer, in procuring tools and in making provision for washing out deposits was $9,893.68

ROCK ISLAND BRIDGE AND SHEER BOOM.

The sheer boom mentioned in my last report has been completed, anchorages for it obtained, and the boom placed in position and used during this summer.

No work has been done on the bridge during the year except that required for ordinary care and preservation.

Appended hereto is a statement, marked Appendix C, of the principal traffic on the bridge during the year.

As you are aware, no collections from the Chicago, Rock Island and Pacific Railway Company on account of freight have yet been made under the act of Congress approved March 3, 1881. All the papers relating to this matter were sent to you February 21, 1882.

APPENDIX A.

ROCK ISLAND ARSENAL, ILL.,
May 15, 1882.

SIR: I have the honor to submit the following report, with accompanying tables, showing amount, kind, and cost of iron rolled at this arsenal, with other data. The mill was started on the 6th of March, and the rolling finished on the 14th of April, 1882.

KIND OF IRON USED.

The iron used for rolling was received from the National Armory, Springfield, Mass., in bars averaging 10 feet in length, and of different cross-section, varying from 1¼ by ¼ inch to ¾ by ¾ inch.

Specimens were taken from this iron and tested in the Rodman machine. One of them gave an elastic limit of 32,910 pounds, and broke at 52,327 pounds per square inch; and another an elastic limit of 22,635 pounds and a breaking weight of 48,665 pounds per square inch.

METHOD OF PREPARING THE IRON FOR ROLLING.

As the iron was in bars of nearly uniform cross section it was thought that it could be cut in lengths under the shears, and piled and rolled without blooming and reheating. The size of the piles for the different sizes of iron rolled was determined as follows:

The diameter of the bar and its length being given its weight was known. Allowing a proper percentage for loss of weight in heating and rolling, the weight of the pile required was also known. It only remained then to find the relation between length of pile and area of cross-section, in order to allow the proper amount of working, and give a length convenient for handling in the rolls. With regard to the proper length of the pile, it was found by trial that 4 feet 6 inches was the greatest length that could be handled to advantage in the furnace, and 1 foot 6 inches the shortest that could be worked conveniently in the rolls. Between these limits, therefore, any convenient length could be given to the pile, which would allow a cross-section of sufficient area to give the required working in the rolls. The lengths of the piles used for each kind of iron are shown in table No. 3. As will be seen from this table the lengths of the piles varied from about 3 feet to 1 foot 10 inches for the different sizes of iron. Many of these variations in size were made for the purpose of determining the effect of more or less working.

The iron was at first piled with all the bars parallel, and of the same length, and bound together with iron wire. It was found, however, that as soon as the iron became heated in the furnace, and it was necessary to turn it, the bars would spread and fall apart. In order to remedy this, two layers of bars at right angles to the length of the pile were placed at top and bottom to form a bond and hold the bars together. This was found to answer the purpose, but the results given by the testing machine showed that the strength of the iron, in the longer bars at least, was impaired by it, and it was therefore abandoned.

The plan was then tried of piling all the bars longitudinally, and clamping them together at each end with two bars bent at right angles to the size and shape of the pile, and the ends turned over. When tried it was found to hold the pile together, but the objection to it was that the bands dragged on the bottom of the furnace and interfered with the handling of the piles in heating.

A modification of the plan was then tried. The clamps were put on as before and a layer of bars added above and below the clamps, which gave a smooth surface in the furnace and held the piles together without difficulty. This plan was afterwards used throughout the work whenever the clamps were necessary, and it was found to work well.

LOSS OF WEIGHT IN HEATING AND ROLLING.

At first the amount of loss by heating and rolling for this particular iron was not known. The amount generally allowed varies from 10 to 25 per cent., but, as the iron was comparatively clean and free from oxide, it was thought that 10 per cent. would cover all losses except for the largest sizes. It was found, however, that this allowance was not great enough, and 15 per cent. was allowed for all the larger sizes down to and including 1 inch diameter, and 10 per cent. for all sizes under 1 inch. It was found, as was to be expected, that the loss generally increased with size of pile. Attempts were made to determine exactly the loss of weight for the different sizes. Table No. 2 shows the results obtained by carefully weighing the piles before they were placed in the furnace, and the bars made from them. The results obtained, especially for the larger sizes, are very irregular, but, as only a small number of the larger sizes were rolled, no good opportunity was afforded of getting an average result that would be reliable. For the 1¼, ⅞, and ¾ inch the results are more reliable, but it was found practically that the allowance above given, of 15 per cent. for sizes down to and including 1 inch, and 10 per cent. for sizes below, was sufficiently accurate for all purposes.

The percentage of loss is given in weight of bar, so that knowing this weight, and adding to it the percentage of loss, the weight of the pile will be obtained.

RESULTS OF TESTS AS TO QUALITY OF IRON.

Table No. 3 shows the results of tests of the iron rolled, as regards elasticity and tensile strength. The first column gives the size of the bar rolled; the second, the size of the pile from which it was made; the third, the area of the bar; fourth, area of pile; fifth, ratio of area of bar to area of pile. The object of this column is to show the amount of working each bar received. The sixth column shows the diameter of specimen before breaking; the seventh, diameter after breaking; eighth, area of cross-section of specimen before breaking; ninth, length of specimen after breaking; tenth and eleventh, the elastic limit and tensile strength per square inch of section. The specimens were all 10 inches in length between shoulders.

It has been shown by experiment that for any given iron the elasticity and tensile strength depend principally on the amount of working the iron receives in the rolls, and that by giving the same amount of working to iron of different sizes the elasticity and tensile strength may be kept nearly constant. Beyond a certain point, however, iron may be overworked and its quality injured. One of the objects of these tests, therefore, was to determine the amount of working which would for this iron give the best results. From the table it will be seen that the results obtained are irregular, so that for the same amount of working in different bars the same elasticity and tensile strength are not obtained, and it is also seen that there is a certain amount of working which does not give a good result, apparently because it is not sufficient; and that beyond a certain amount again the strength of the iron is reduced because of too much working. The greatest ratio of area of bar to pile, and consequently the greatest amount of working given, is 36.5 in the case of one of the ⅞-inch bars, and the tensile strength and elastic limit of the specimen were greatly exceeded in other bars with a less amount of working.

From the results obtained it is believed that the proper ratio and the one giving the best results lies between 20 and 25, as above and below each of these points there appears to be a falling off in the strength of the iron. Within the limits 20 to 25, however, there is considerable irregularity in elasticity and tensile strength. In examining the specimens after fracture in the machine, some peculiarities were observed, which it is thought may, in some degree, explain some of the variable results obtained. Whenever a specimen which gave a poor result in testing was examined carefully, the outside showed longitudinal streaks, along which the fibers or crystals had apparently been extended throughout the whole length of the specimen; and other streaks were also observed in the same specimen where the smooth, silvery appearance of the surface was preserved, and along which the fiber had apparently not been extended at all, at least not to such a degree as the adjacent portions. These streaks were very well marked in the specimens. On examining the surfaces of fracture, black lines, well defined, were observed, extending across the bar, and it is believed that these lines marked the surfaces of the original bars where they had been imperfectly welded in rolling. These lines were generally found to bound the part of the bar whose outside presented the silvery appearance before mentioned, and which showed that they were not strained to such an extent as the adjacent parts.

On the other hand, with a specimen which gave a good result in testing, the fracture was uniform and fibrous without showing any of the appearances mentioned, and the outside of the specimen gave indications that all the fibers of the bar had been uniformly acted on by the strain. It is thought that these appearances indicate that in the one case the welding of the bars has not been properly done by the rolls, and, consequently, the different bars composing the rolled bar are strained to a different degree by the same force; while, where the welding is properly done, we have a homogeneous mass of iron, all of whose particles are equally strained and brought to the breaking point at the same time. How much of the irregularity in strength may be due to improper welding, and how much to under and over working, cannot be determined, but the general results show that the best iron was obtained between the ratios 20 and 25.

It is believed that a better result would be obtained if the iron were first piled in flat piles and run out into thin slats, then these slats cut in the shears and piled heated and rolled.

This plan was adopted in rolling the 3 and 3½ inch shafting, and, although no tests of the iron have as yet been made, its appearance would seem to indicate that the result obtained is rather better than by the method followed with the smaller iron. The whole question, however, is one of relative cost. If the iron can be obtained by the first method of sufficiently good quality to answer the purpose for which it is intended, it will be much cheaper than by the method of slatting and repiling, as is shown in the case of the 3-inch shafting.

THE 3 AND 3½ INCH SHAFTING.

After finishing the smaller sizes of round iron for the roof rods it was decided to roll 30 pieces each of 3 and 3½ inch shafting, each piece to be 20 feet long. No rolls were at hand of the proper size to do this work, and after an attempt to procure them from different places without success it was determined to cast and turn them at the arsenal. This was successfully done, and the rolls worked perfectly when finished. There seemed to be some doubt as to whether the turning could be successfully accomplished with the appliances at hand, as there was no special machine for roll turning at the arsenal, and the rolls had to be turned in a large lathe. In addition to this, none of the workmen had had any experience in roll turning.

The difficulty in using the lathe for this purpose was, that on account of the weight of the casting, and from the fact that the lathe centers would rest against the softest and most porous part of the casting, there was some danger that the bearings would wear irregularly and produce an irregularity in the grooves. This difficulty was overcome by the insertion of hollow steel bearings in the ends of the casting, against which the lathe centers rested. This plan was suggested by Mr. Shunk, foreman of the machine shop, and a slight modification made by Mr. Drayton, master machinist.

An accurate drawing of the grooves having been made, special cutting tools were made of the exact shape required for each groove. The grooves were first cut out roughly with an ordinary cutting tool, and then finished with the special tool.

For the 3-inch shafting the bars were first cut to lengths of 3 feet 8 inches and piled 3 feet 8 inches by 5½ by 3 inches, weighing 162 pounds. These were then heated and rolled down to a slab 4 feet 6 inches by 6½ by 1½ inches; weight 150 pounds. Four of these slabs were then piled, 4 feet 6 inches by 6½ by 6 inches, weighing 600 pounds, and rolled into a bar 20 feet long and 3 inches diameter. It was found necessary to reheat all these piles for the 3-inch shafting after two passes through the roughing rolls, and hence only three of them could be handled at one heat. It was intended to roll the 3½ inch into bars 20 feet long, but it was shown from the rolling of the 3 inch that weights greater than 600 pounds could not be handled without some mechanical contrivance for taking the iron from the furnace and carrying it to the rolls, and in fact the mill would not take any longer pile. It was therefore decided to roll the 3½ inch into lengths of 11 feet and weld them. This required 3 slabs, making a pile 4 feet 6 inches by 6½ by 4 inches; weight 450 pounds. This shafting was rolled with much less difficulty and labor than the 3 inch and at about one-half the cost.

AMOUNT AND KIND OF IRON ROLLED.

Table No. 1 shows amount of each kind of iron rolled. A table was prepared showing the amount of each kind of iron required, and this was followed as closely as possible. The amount rolled is slightly in excess of that required, as will be seen by the table when the amount required by the bill is given. This excess is owing to the fact that the ends cut off from the roof rods are counted in the amount of iron rolled. There is a slight deficiency of the 1⅞ and 1⅜ inch round and 1¼ inch square.

The whole weight of iron rolled is 280,381 pounds, or $125\frac{381}{2240}$ tons.

COST OF IRON ROLLED.

This is shown in table No. 4. The cost of labor and fuel is alone considered, and the repairs and other incidental expenses are given separately; the estimated value of the iron used in rolling is also left to be added. The total amount of fuel used for the boilers is 940 bushels, or $33\frac{1280}{2240}$ tons, shavings having been used as the principal fuel during the rolling.

Respectfully submitted.

LAWRENCE L. BRUFF,
Lieutenant of Ordnance.

COMMANDING OFFICER,
Rock Island Arsenal.

TABLE No. 1.—*Showing amount and kind of iron rolled at Rock*

Date.	Diameter.									
	1½ inches.	1⅝ inches.	1¾ inches.	1⅞ inches.	2 inches.	2⅛ inches.	2¼ inches.	2⅜ inches.	2½ inches.	1⅜ inches.
1882.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*
March 6	3,818	2,489	1,235	1,490						
7					1,445	2,981	1,527	1,243	2,400	
8							7,412			
9	158			314	8,254		2,037			
* 10										
11				4,417	1,086	221	3,072			
13		6,864	378	1,413						520
14	1,230	5,952	2,730							
15	10,124									363
16										11,325
17	396	216			682			503		127
18										
20										
21										
22										
23										
24										
25										
27										
28										
29										
30										
31										
April 1										
3										
4										
5										
6										
7										
8										
10										
11										
12										
13										
14										
Total amount of each kind rolled	15,726	15,521	4,343	7,634	11,467	3,202	14,048	1,746	2,400	12,335
Total amount to be rolled, weight	13,396	12,819	3,729	8,128	10,195	2,313	12,746	1,659	2,008	13,600
Excess	2,330	2,702	614	‡ 494	1,272	889	1,302	87	392	‡ 265

Whole weight of iron rolled,

* No iron rolled.

‡ Deficiency.

Island Arsenal, with amount of fuel consumed, and cost of labor.

Square grate bars, 1⅛ inches.	Square roof iron, 1¼ inches.	1 inch.	1¼ inches.	1⅛ inches.	⅞ inch.	¾ inch.	Shafting, 3 inches.	Shafting, 3¼ inches.	Fuel.		Cost of labor per day.
									Furnace.	Boilers.	
Lbs.	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Lbs.*	*Bushels.*	*Bushels.*	
									429	103	$71 45
									108	52	79 98
									56		77 57
									155		77 91
									41		25 92
									95		81 55
									137		81 95
									104		82 25
									100		81 70
									153		79 90
3,612	2,892	306							153		79 90
			9,743						157		88 43
			10,401						106		79 75
130			11,009						156		80 45
			10,452						103	48	80 45
184			5,389	5,072					156	45	80 44
				11,310					52		79 65
		946		9,878					153		88 42
		10,460							103	107	79 90
		6,307			4,153				156		80 02
					9,775				157		79 90
					8,642	377			50		80 02
						7,677			155	105	79 90
						7,586			102		80 37
						7,727			152		77 02
						4,318			167		76 27
							(†)		109	54	77 80
							(†)		106		77 82
							4,506		110	55	73 55
							4,454		110	56	73 55
							5,060		162	162	84 78
							1,437		107		76 97
									106	55	80 15
								11,195	165	55	75 65
							2,272	14,689	104	43	120 45
3,926	2,892	18,019	46,994	26,260	22,570	27,685	17,729	25,884			
	3,168	17,000	45,711	24,784	20,866	26,770	14,323				
3,926	‡276	1,019	1,283	1,476	1,704	915	3,406				

280,381 pounds, or 125 $\frac{381}{2240}$ tons.

† Slabs for 3-inch shafting.

TABLE No. 2.—*Showing loss of weight in iron by heating.*

Number.	Size of bar.	Size of pile.	Weight of pile before heating.	Weight of bar after rolling.	Loss of weight.	Per cent of loss in weight of bar.	Average loss.
	Diameter. "	' " " "	*Pounds.*	*Pounds.*	*Pounds.*		
1	2⅛	2 10 x 5 x 5	185	178	7	.039	.051
2	2⅛	2 10 x 5 x 5	185	174	11	.063	
3	1⅞	2 9 x 5½ x 5½	240	221½	18½	.083	.1348
4	1⅞	2 9 x 5½ x 5½	240	222	18	.081	
5	1⅞	4 7 x 5 x 5	317	271	46	.17	
6	1⅞	4 7 x 5 x 5	317	271	46	.17	
7	1⅞	3 1 x 5½ x 6½	317	271	46	.17	
8	1¾	1 1 x 6 x 7	200	168	32	.19	.174
9	1¾	2 9 x 5½ x 4½	200	180	20	.11	
10	1¾	4 7 x 4 x 4	120	99	21	.21	
11	1¾	1 1 x 4½ x 5½	120	101	19	.188	
12	1⅝	2 3 x 4½ x 5½	175	158	17	.107	.079
13	1⅝	2 9 x 4 x 5	170	161½	8½	.052	
14	1⅝	2 2 x 5 x 5	143	135	8	.058	067
15	1⅜	2 2 x 5 x 5	140	130	10	.076	
16	2	2 1 x 7 x 5½	215	201	14	.069	.069
17	1¼	2 1 x 4½ x 5½	138	119	19	.159	.083
18	1¼	2 1 x 4½ x 5½	138	129	9	.069	
19	1¼	2 1 x 4½ x 5½	138	129	9	.069	
20	1¼	2 1 x 4½ x 5½	138	131	7	.053	
21	1¼	2 1 x 4½ x 5½	138	131	7	.053	
22	1¼	1 10 x 6 x 6½	203	186	17	.091	
23	1¼	1 10 x 6 x 6½	203	186	17	.091	
24	1⅛	2 3 x 4½ x 5½	155	140	15	.107	.084
25	1⅛	2 1 x 4½ x 5½	140	128	12	.093	
26	1⅛	2 1 x 4½ x 5½	140	135	5	.037	
27	1⅛	2 x 4 x 5	120	109	11	.10	
28	1	2 1 x 4½ x 5½	138	127	11	.086	.132
29	1	2 1 x 4½ x 5½	138	122	16	.131	
30	1	2 0 x 4½ x 5½	125	106	19	.179	
31	⅞	1 10 x 4 x 4½	90	81	9	.111	.802
32	⅞	1 10 x 4 x 4½	90	85	5	.0588	
33	⅞	1 10 x 4 x 4½	90	87	3	.034	
34	⅞	1 10 x 4 x 4½	95	85	10	.117	
35	¾	1 10 x 3½ x 4	68	58	10	.17	.0857
36	¾	1 10 x 3½ x 4	68	66	2	.03	
37	¾	1 10 x 3½ x 4	68	67	1	.015	
38	¾	1 10 x 3½ x 4	68	62	6	.096	
39	¾	1 10 x 3½ x 4	68	60	8	.133	
40	¾	2 0 x 3½ x 4	70	66	4	.06	
41	¾	1 10 x 3½ x 4	68	62	6	.096	

TABLE No. 3.—*Table of comparison of iron rolled at Rock Island Arsenal, March,* 1882.

Size of bar rolled, diameter.	Size of pile.	Area of bar.	Area of pile.	Ratio of area of bar and pile.	Diameter before breaking.	Diameter of rupture.	Area of cross-section before rupture.	Length after breaking.	Elastic limit, per square inch.	Breaking weight per square inch.
Inches.	' " ' "	*Sq. inch.*	*Sq. in.*		*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*		*Pounds.*
2⅛	2 9 x 6 x 6	3.5465	36	10.151	1.000	....	0.7854	12.65	21,645	46,027
1½	2 0 x 5 x 5	1.7671	25	14.147	0.989	0.8	0.7682	5⅛	(*a*)	53,006
1½	2 0 x 5 x 5	1.7671	25	14.147	0.993	0.7	0.7744	5⅝	(*a*)	48,680
1½	2 0 x 5 x 5	1.7671	25	14.147	0.989	0.755	0.7682	5 3/16	(*a*)	54,400
1½	2 0 x 5 x 5	1.7671	25	14.147	1.000	0.92	0.7854	11.8	35,650	53,488
2⅛	3 9 x 6 x 6	3.5465	36	10.151	0.975	0.73	0.7466	12.5	21,428	44,200
2	2 10 x 6 x 6	3.1416	36	11.46	1.000	0.761	0.7854	12	21,645	44,563
(*b*)	(*c*)	(*d*)	(*d*)	(*d*)	0.622	0.442	0.3038	13.95	32,910	52,327
2⅛	2 10 x 5 x 5	3.5465	25	7.0493	1.000	0.850	0.7854	12	20,371	44,563
1⅞	2 10 x 5 x 5	2.7611	25	9.0593	1.000	0.680	0.7854	13.1	19,098	44,690
1⅞	2 10 x 5 x 5	2.7611	25	9.0593	1.000	0.704	0.7713	13	24,633	44,923
2⅛	2 10 x 5 x 5	3.5465	25	7.0493	0.991	0.685	0.7854	13.1	22,918	45,454
1½	2 10 x 5 x 5	1.7671	25	14.147	1.000	0.690	0.7698	12.6	22,085	46,118
2⅛	2 10 x 5 x 5	3.5465	25	7.0493	0.990	0.704	0.7854	12.7	25,464	47,619
2⅛	2 10 x 5 x 5	3.5465	25	7.0493	1.000	0.750	0.7854	12.8	20,371	46,091
1⅞	2 9 x 5½ x 5½	2.7611	30.25	10.956	1.000	0.730	0.7854	12.8	26,738	47,619
1⅞	2 9 x 5½ x 5½	2.7611	30.25	10.956	1.000	0.754	0.7854	13.1	25,464	47,619
1⅞	4 7 x 5 x 5	2.7611	25	9.0543	1.000	0.623	0.7854	12.4	21,645	45,582

TABLE NO. 3.—*Table of comparison of iron rolled at Rock Island Arsenal, &c.*—Cont'd.

Size of bar rolled, diameter.	Size of pile.	Area of bar.	Area of pile.	Ratio of area of bar and pile.	Diameter before breaking.	Diameter of rupture.	Area of cross-section before rupture.	Length after breaking.	Elastic limit, per square inch.	Breaking weight, per square inch.
Inches.	′ ″ ′ ″	*Sq. inch.*	*Sq. in.*		*Inches.*	*Inches.*	*Sq. inches.*	*Inches.*		*Pounds.*
1⅞	4 7 x 5 x 5	2.7611	25	9.0543	1.000	0.710	0.7854	13	21,645	44,818
1⅞	3 1 x 5½ x 6½	2.7611	35.75	12.947	1.000	0.684	0.7854	12.6	24,191	46,218
1¾	1 1 x 6 x 7	2.4052	42	17.462	1.000	0.72	0.7854	12.8	21,645	45,964
1¾	2 9 x 4½ x 5½	2.4052	24.75	10.290	1.000	0.71	0.7854	12.7	21,645	45,964
1¾	4 7 x 4 x 4	2.4052	16	6.652	1.000	0.72	0.7854	13.1	21,645	45,964
1¾	1 1 x 4½ x 5½	2.4052	24.75	10.290	1.000	0.756	0.7854	12.9	21,645	47,619
1½	2 3 x 4½ x 5½	1.7671	24.75	14.006	1.000	0.674	0.7854	13	25,464	48,510
1½	2 9 x 4 x 5	1.7671	20	11.318	1.000	0.670	0.7854	13	25,464	46,728
1⅜	2 2 x 5 x 5	1.4849	25	16.836	1.000	0.690	0.7854	13	26,738	46,855
1⅜	2 2 x 5 x 5	1.4849	25	16.836	1.000	0.673	0.7854	13.1	25,464	46,601
2	2 1 x 7 x 5½	3.1416	38.5	12.254	1.000	0.695	0.7854	13.1	24,191	47,110
1¼	2 1 x 5½ x 4½	1.2271	24.75	20.169	0.850	0.550	0.5674	12.5	24,674	43,356
1¼	2 1 x 5½ x 4½	1.2271	24.75	20.169	0.850	0.515	0.5674	12.8	29,961	44,060
1¼	2 1 x 5½ x 4½	1.2271	24.75	20.169	0.800	0.561	0.5027	12.9	35,810	48,940
1¼	2 1 x 5½ x 4½	1.2271	24.75	20.169	0.800	0.606	0.5027	12.5	35,810	51,726
1¼	2 1 x 5½ x 4½	1.2271	24.75	20.169	0.792	0.5	0.4926	12.9	28,417	47,701
1¼	1 10 x 6 x 6½	1.2271	39	31.782	0.800	0.543	0.5027	12.6	27,852	49,338
1¼	1 10 x 6 x 6½	1.2271	39	31.782	0.800	0.543	0.5027	12.6	25,863	49,338
1⅛	2 3 x 4½ x 5½	0.9940	24.75	24.899	0.805	0.57	0.5089	13.1	31,437	47,942
1⅛	2 1 x 4½ x 5½	0.9940	24.75	24.899	0.750	0.555	0.4418	12.1	27,163	48,667
1⅛	2 1 x 4½ x 5½	0.9940	24.75	24.899	0.805	0.525	0.5089	13	25,542	48,335
1	2 1 x 4½ x 5½	0.7854	24.75	31.513	0.805	0.682	0.5089	12.1	19,648	47,549
Square.										
¾ x ¾	(*d*)	(*d*)	....	....	0.750	0.475	0.4418	12.5	22,635	48,665
1⅛	2 0 x 4 x 5	0.9940	20	20.121	0.805	0.572	0.5089	12.7	23,578	51,085
1	2 1 x 4½ x 5½	0.7854	24.75	31.513	0.800	0.584	0.5027	12.7	21,884	49,338
1	2 0 x 4½ x 5½	0.7854	24.75	31.513	0.805	0.39	0.5089	13	27,508	50,300
⅞	1 10 x 4 x 5½	0.60132	22	36.586	0.592	0.44	0.2753	12	25,431	48,683
⅞	1 10 x 4 x 4½	0.60132	18	29.934	0.630	0.425	0.3117	12	28,872	....
⅞	1 10 x 4 x 4½	0.60132	18	29.934	0.506	0.31	0.2011	12	24,864	48,237
⅞	1 10 x 4 x 4½	0.60132	18	29.934	0.630	0.37	0.3117	12.5	25,664	46,837
¾	1 10 x 3½ x 4	0.4418	14	31.689	0.600	0.39	0.2827	12.5	24,758	47,747
¾	1 10 x 3½ x 4	0.4418	14	31.689	0.630	0.43	0.3117	12.5	21,814	47,478
¾	1 10 x 3½ x 4	0.4418	14	31.689	0.630	0.54	0.3117	12.2	23,097	51,008
¾	1 10 x 3½ x 4	0.4418	14	31.689	0.630	0.423	0.3117	12.1	25,022	48,761
¾	1 10 x 3½ x 4	0.4418	14	31.689	0.625	0.424	0.3068	12.8	22,817	49,546
¾	2 0 x 3½ x 4	0.4418	14	31.689	0.635	0.415	0.3167	12.5	22,104	49,575
¾	1 10 x 3½ x 4	0.4418	14	31.689	0.630	0.41	0.3118	11.7	21,815	47,800
¾	2 0 x 3½ x 4	0.4418	14	31.689	0.630	0.475	0.3118	11.3	38,496	57,423

a Not taken. *b* Not rolled. *c* Not known. *d* Unknown.

TABLE NO. 4.—*Showing cost of iron rolled at Rock Island Arsenal.*

Kind of iron.	Amount rolled.	Cost of labor.	Cost of fuel.	Total cost.	Cost per pound.
	Pounds.				
1¼-inch diameter	15,726	$126 78	$40 18	$166 96	$0.0106
1½-inch diameter	15,521	135 68	38 98	174 66	.01125
1⅝-inch diameter	4,343	36 56	12 38	48 94	.011268
1⅞-inch diameter	7,634	69 21	19 52	88 73	.011623
2-inch diameter	11,467	88 95	22 54	111 49	.009722
2¼-inch diameter	3,202	27 67	5 16	32 85	.010239
2½-inch diameter	14,048	136 87	20 06	156 93	.011171
2⅝-inch diameter	1,746	14 84	3 22	18 06	.010344
2¾-inch diameter	2,400	20 92	3 88	24 80	.010333
1⅜-inch diameter	12,335	91 21	23 23	114 44	.0092776
1⅛-inch square grate bars	3,926	36 44	9 51	45 95	.011704
1¼-inch square roof iron	2,892	27 26	7 06	34 32	.011867
1-inch diameter	18,019	143 44	33 75	177 19	.0098335
1¼-inch diameter	46,994	379 74	91 37	471 11	.010025
1⅛-inch diameter	26,260	204 45	37 36	241 81	.0092083
⅞-inch diameter	22,570	194 04	42 96	237 00	.010501
¾-inch diameter	27,685	326 69	88 95	415 64	.015013
3-inch shafting	17,729	501 17	139 57	640 74	.036982
3½-inch shafting	25,884	321 11	63 10	384 21	.01484
Total	280,381	2,883 05	702 78	3,585 83	....

OTHER EXPENSES IN ROLLING MILL.

Machine shop.	Cost.	Carpenter shop.	Material.	Labor.
Fitting up mill to run	$27 20	Putting on belts and repairing machinery		$26 00
Repairing tools and fixtures	57 94	Making patterns for rolls	$2 00	10 80
Repairing furnace	17 33	Making patterns for guides	40	13 50
Making iron straps for piles	14 48	Making water trough (casting)	4 00	1 80
Turning and testing samples	85 72	Making mauls and handles and repairing tools		3 15
Total	202 67			
		Total	6 40	55 25
				6 40
				61 65
				202 67
Total amount				264 32
One pair rolls				177 73

Estimated weight of iron used, 329,860 pounds, at 1 cent=$3,298.60.

SUMMARY.

Bar iron manufactured, 236.768 pounds, worth 3½ cents per pound		$8, 287 88
Shafting manufactured, 43,613 pounds, worth 4½ cents per pound		1, 942 63
Total		10, 230 51
COST.		
Labor	$2, 883 05	
Coal	702 78	
Freight on 165 tons iron from Springfield, at $5.60 per ton	924 00	
Cost of one pair of rolls	177 73	
General expenses, repairs, &c	264 32	
Total		4, 951 88
Saving		5, 278 63
Estimated value of 165 tons scrap at Springfield, at $15 per ton		2, 475 00
Leaves		2, 803 63

APPENDIX B.

(See Plates III and IV.)

In 1871, foreseeing the importance, in connection with plans for the transmission of power, of having the water-power dam parallel to the lines of the shops, no matter what plan for transmission I might finally adopt, I made a preliminary survey to see if the dam could be so placed. At that time only Shops B and C were built or partially built. The surveyor was several hours in getting an accurate base line by prolonging the lines of one of these shops; and seeing then the difficulty and great danger of error in using such lines for future surveys, I at once established the bench-mark lines on Main avenue and West avenue, marked by the cut-stone posts and copper plugs at corner of West and North avenues, corner of Main and West avenues, and corner of Main and East avenues. (For reasons given further on, the latter has lately been moved 2$\frac{1}{16}$ inches south, and also east across East avenue, but the latter move has no effect on the east and west line it established.)

I then gave careful orders that all future surveys should be made from these bench-mark lines, particularly in laying out the shops, lines of shafting, the dam, and transmission lines.

I have lately discovered that this order has been uniformly disobeyed, and the result is as shown on Plate III.

The lines of shops have been laid out by trying to follow the lines of Shops B and C as first established. The result is that the west end of the arsenal row is 7¾ inches nearer the Main avenue bench-mark line than the east end, and the west end of the armory row is 2¾ inches farther from the same line than the east end, making the distance between the two lines of shops 5 inches less at the west end than at the east end. Again, by trying to make surveys from these undeterminate lines, the water-power dam was so laid out that its east end is fully 4.29 inches too far south for the position of its west end. Then, again, in surveying for the great water-power shaft, an attempt was made to follow the erroneous lines of the dam, but so unsuccessfully that the line of the shaft prolonged to the east end of the dam departs 13.66 inches north from a line parallel to the dam, making the total departure of this water-power shaft line north, at the east end, from a line parallel to the B. M. line, nearly 8 inches. (This departure is in the 656 feet of dam between centers of the two extreme counterforts.) This is all shown on Plate III. In June, 1882, when these errors were discovered, a line parallel to the water-power shaft was prolonged to D; then the perpendicular line *Dm* was surveyed, and the lines *ef*, *gh*, *kl*, and *mn*, all parallel to the water-power shaft, were then laid off with the results shown on the drawing. The drawing also shows that the lines for the temporary wire-rope transmission had not been accurately surveyed.

The lines of shafting in Shops A and C had been put up prior to this survey, and measurements showed that they had been placed parallel to the erroneous lines of Shops A and C, instead of perpendicular to the bench-mark line BC, as they should have been. This has made the south end of these lines (300 feet long) depart to the west about 1½ inches.

In making careful surveys (in June, 1882), to correct and adjust these discrepancies I found, first, that the bench-mark line BC on Main avenue, was not exactly perpendicular to the bench-mark line AB on West avenue, as it should be. The east end, C, was 2$\frac{1}{16}$ inches too far north. I then moved the post C 2$\frac{1}{16}$ inches south, as has been stated.

The reasons for this were as follows: It is necessary that angle at B, between the two bench-mark lines, should be a right angle.

Some important surveys have been made from the line AB, and this line could not be changed.

The great transmission shafts which are to run through both the armory and arsenal rows of the shops (see lines EF and HK, on Plate IV) are to be parallel to the line BC, and it is important that these shafts should be as nearly as possible parallel to the rows of shops. The move of the stone C makes these lines more nearly parallel. It leaves the divergence between the line BC and the armory shaft EF only $\frac{11}{16}$ inch in 1,588 feet, which is less than the limit of accuracy in setting shafting. The piece of the shaft EF, and the large engine in Shop F, are now set to the lines of Shop F, and need not therefore be corrected. It leaves the divergence of the arsenal row of shops from the line BC, and consequently from shaft HK, 5$\frac{11}{16}$ inches in 1,588 feet.

The main lines of shafting in Shops A and C having been already set to the lines of the shops, and it being absolutely necessary that they should be placed exactly perpendicular to the transmission shaft HK, it makes their divergence in their whole length, 300 feet, a little less than one inch, their south ends being too far west. It will therefore be necessary when the transmission shaft HK is laid and connected with the shop main lines of shafting to adjust the latter by moving their south ends about $\frac{1}{2}$ inch east and their north ends about $\frac{1}{2}$ inch west. The hanger-bolt holes admit of this amount of adjustment without moving the bolts.

I have set copper plugs in the window sills at *a*, *b*, *c*, *d*, *e*, *f*, *g*, and *h*, to establish accurately the required direction of main lines in Shops A and C, and will place other plugs similarly in all of the shops.

For greater convenience in using the bench-mark line BC, I established another stone, O, midway on this line. Having established the new bench-mark line BC on Main avenue, as has been described, I then laid off a right angle at C, and set the stone D, establishing the new bench-mark line CD perpendicular to BC. The north and south lines of the permanent transmission, when built, are to be established accurately parallel to CD.

Finally I extended the line CD to M′; laid off a right angle at M′, and put copper plugs in the dam wall at M and N, thus making very carefully and accurately a line parallel to the proper and required position of the great lines of water-power shafting on the dam.

One hundred and two feet of this great shaft are already laid and erroneously laid. As shown on Plate IV, the east end is too far north, and would depart from the correct line 7.95 inches in 656 feet. This line must be corrected whenever the permanent transmission is built. It is proposed to make the correction by leaving the shaft unmoved over the first water-wheel, and moving the east end of the shaft nearly $\frac{3}{4}$ of an inch south, and the west end about $\frac{46}{100}$ north. This will leave water-wheel No. 1 unmoved, and require that wheel No. 2 be moved $\frac{1}{5}$ inch south; wheel No. 3 $\frac{2}{5}$ inch south, and wheel No. 4 $\frac{3}{5}$ inch south. This readjustment of the water-power shaft is not objectionable because of what follows.

At the time the water-power dam was planned and constructed, I placed its top line above the level to which any high water ever known in this region would have raised the water in the pool. The high water of June, 1880, raised the water in the pool 8 inches above the dam. In consequence of this, and to meet the probable still higher rises in the future, due to cutting away forests in Wisconsin and Minnesota, I believe it to be necessary to raise the dam 2 feet. This work need be done only as water-wheels are set, and the wheel-house is extended, leaving the water to flow over the unoccupied part of the dam in case such high water occurs again. To meet the pressure on this increased height of dam, it is necessary that the counterforts should be raised also. If the counterforts are raised, it will of necessity raise the water-power shaft. My experience with the water-power and with the temporary transmission now in operation convinces me that the shaft should be raised 4 feet. If then wire-rope transmission is used with driving pulleys 24 feet in diameter, as I propose, it will not be necessary to further deepen the pulley and wire-rope pit under the pulley-house. It should not be further deepened because of the difficulty in contending with back water in the pit, in times of very high water.

If bevel-gears and north and south lines of shafting are used instead of wire ropes (I now think that upon further examination this latter plan will be deemed more advantageous than the wire rope), then this raise of the shaft will be very desirable, because it will diminish the objectionable slope of the north and south lines of shafting, and will also diminish the depth of excavation required between South and North avenues.

This raising the shaft 4 feet will require raising the counterforts 4 feet. This further raising of the counterforts will strengthen the dam still more, which I deem important. Then to strengthen the counterforts, which may be desirable on account of their increased heights and for other important reasons, I think it desirable to abandon the 6½ feet of iron partitions between the penstocks, and replace it by extending the counterforts down stream south, to the extreme south line of penstocks, and enough farther to allow 3 feet of batter on the south ends on the counterforts. I would also use cast-iron angle-iron for fastening the iron penstocks to the counterforts instead of Phœnix half columns, it being quite as good and much cheaper. As it will be necessary whenever new wheels are set to coffer and bare the bottom of the river to excavate and put in masonry to carry the water-wheel floors, this extension of the counterforts can be then made without much trouble, and will not be much more expensive than the iron partition. The proposed changes in the dam and portion of the water-power shaft are shown in Fig. 2, on Plate IV. The broken lines show the lines of the dam and counterfort, and position of shaft as it is now built.

APPENDIX C.

Abstract of record kept at the Rock Island Bridge during the year.

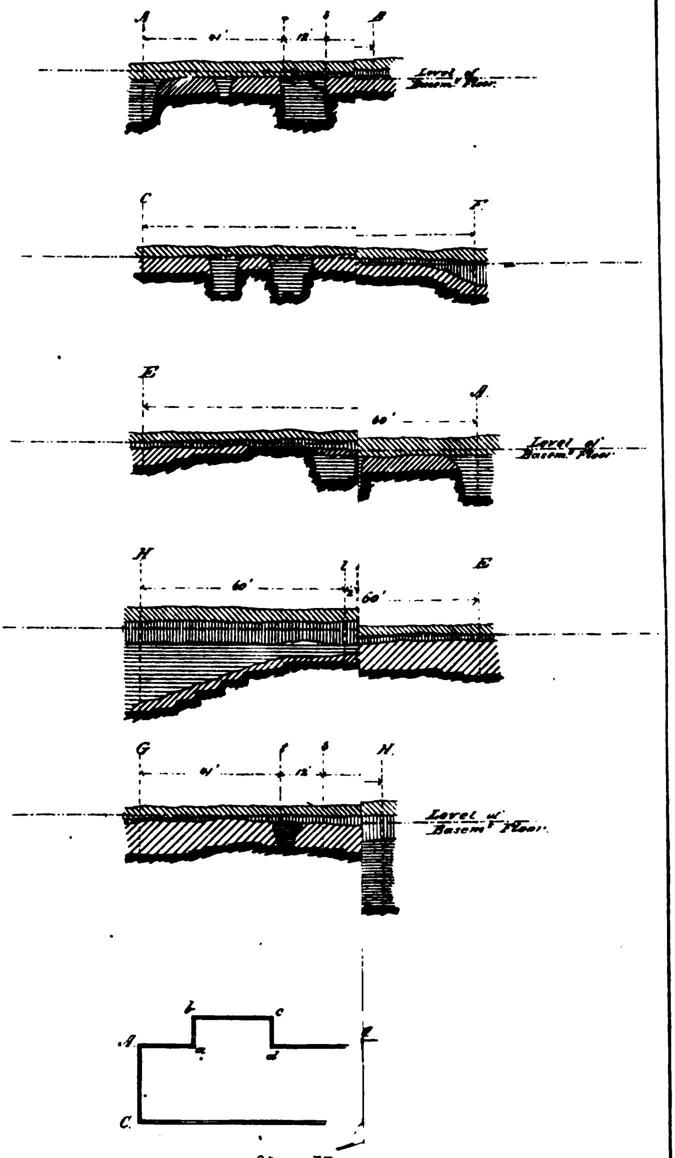
PASSING NORTH.

Engines with trains	6,198
Engines without trains	470
Total engines	6,668
Passenger cars	9,104
Freight cars	109,535
Foot-passengers	242,837
Teams	162,380
Steamboats, up	1,448
Barges	203

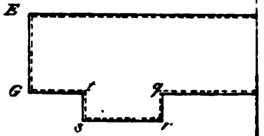
PASSING SOUTH.

Engines with trains	6,267
Engines without trains	356
Total engines	6,623
Passenger cars	9,061
Freight cars	106,191
Foot-passengers	248,203
Teams	164,367
Steamboats, down	1,469
Barges	208
Rafts	1,046

PLATE I.



Shop K.
Plan of Excavati
for Foundatio Feet.



APPENDIX 11.

REPORT OF THE PRINCIPAL OPERATIONS AT THE BENICIA ARSENAL, CALIFORNIA, DURING THE FISCAL YEAR ENDED JUNE 30, 1882.

COL. J. MCALLISTER, ORDNANCE DEPARTMENT, COMMANDING.

BENICIA ARSENAL, CAL.,
August 21, 1882.

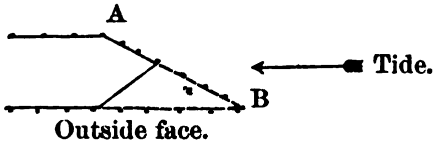
GENERAL: I have the honor to submit the following report of the principal operations at this arsenal during the fiscal year ending June 30, 1882:

TIMBER SHED.

This building is of wood, 142 feet by 30 feet, one story high. The roof projects over sides and gables 3 feet, supported by brackets. The sides are closed by panels; it has six pairs of sliding doors. The floor is divided by three roads at equal distances from each other, and the spaces between roads and gable ends are floored. Teams can drive through it and deposit in it, or remove lumber from it, very easily.

WHARF.

The wharf has been extended on both upper and lower ends thus:



The three inside faces have been sheathed with vertical piles or plank 4 inches thick. Each of these piles has been driven 20 feet into the mud, the upper ends being spiked on to the stringers; one of the latter is at the top and the other at low-water mark on wharf. The tide, therefore, cannot deposit any slickens or *débris* which may come from the land side under this wharf. The tide impinges on inclined face A B, and is forced into the channel between the old and new wharf, scouring it out and keeping the channel between the wharves free of deposit. Up to this time this has proved a success; the water at the front of the old and inside wharf, although the face of the latter is not parallel to the face of the new one nor to the tide line, is still deep enough to allow laden vessels to discharge their cargoes. When the front face of the old wharf is built out parallel to the tide line and sheathed as the new one is, there will be a channel boarded up on each side, with no still water in which *débris* can be deposited.

FREIGHT-HOUSE AT ARMY POINT STATION.

This building is of wood, 40 feet by 20 feet, one story high, with a high front platform on level with the floors of the freight cars, and extending nearly to the side track of the railroad. Two shifting tramways are used to connect the freight cars with platform.

It has two sliding doors opposite each other. Wagons and carts receive and deliver the freight from the door furthest from the track. The roof of this building projects over sides and gables and is supported by brackets. Under the same roof is the waiting room for passengers and the ticket and freight office.

ARTESIAN WELL.

At the termination of the last fiscal year a cartridge of dynamite had been exploded in the well, some 920 feet from the surface, to open the seams in the water-bearing stratum, and thus a final attempt was made to obtain a flowing well. This experiment proved a failure, the water only rising a few feet in the well. No doubt this small rise was due to the large amount of gas which rushed up the well from its subterranean storehouse.

After a few days the water receded to its normal position, *i. e.*, about 15 feet below the surface of the ground. It was ascertained by gauging the interior of the well-hole, that the double sheet-iron casings were bent inwards in some places, and they had to be swedged out to admit the tools employed to bore through the *débris* of iron, rock, and sand which filled the bottom of the well.

The well was chocked up by this conglomerate for 36 feet, this being the effect of the explosion on the pipes and walls of the well; 70 pounds of iron and nearly a ton of shale and rock being removed from the well.

It was ascertained as the above was taken out that the walls and oof of the cavity created by the subterraneous explosion of the petard were continually caving and filling up the well-hole. Before taking any measures to secure the water for use, it was necessary to ascertain the quantity and quality of the water that the well could supply, and what effect, if any, the firing of the cartridge had exercised upon that upply.

A deep-well pump at the end of a two-inch diameter pipe was inserted; this last had an India-rubber packer around it about 40 feet from the bottom, to fill up the well-hole between its outside and the walls of the well, so that none but the water which entered the well from the 920-foot level would be raised by the pump. It was necessary to try to stimate the quality of the water, and the amount and quality of the gas hich could be obtained from this deep source when uncontaminated y water and gas which might enter the well hole from the upper levels. fter these arrangements were completed an endeavor was made to haust the water by pumping continuously night and day for several ys and nights, until all were satisfied that the supply of water furshed by this well was inexhaustible. A rude gasometer was manuctured in which to store the gas coming up with the water.

This natural gas was then examined with a view to employ it in drivg a gas engine to pump the water up out of the well, to heat a steam iler, and for illuminating purposes. It was ascertained that the volme of gas discharged hourly (according to the registry of an ordinary enty-light gas-meter) was exactly 18 cubic feet per hour and of not ore than six-candle power. The whole flow of such a gas would delop in a gas machine not to exceed two-thirds of one horse-power ntinuously, and a careful gasometric analysis would most probably duce even the above estimate.

In reference to using this gas as an illuminating power we were dispointed. An argand burner consumes 5 cubic feet of common coal s per hour, yielding light equal to that of 16 candles. The whole flow of this natural gas would only furnish a light equal to less than one and a half such burners. This gas can be utilized, however, as it has been hitherto, *i. e.*, to save a portion of the fuel expended in the grate of the boiler furnishing steam to the cylinder which is to work the pump when there is no wind to propel the fans of the mill.

This natural gas is of the nature of fire-damp or marsh gas; there are no traces of sulphur in it and it is inodorous.

To make this well a permanent source of water to the government it was necessary to protect its walls in a substantial manner from caving through its whole extent of 938 feet. It was anticipated that this could be effected by employing the 7-inch artesian wrought-iron well tubing received from Philadelphia, and the joints of which would be water tight when screwed together.

On gauging the well, however, it was ascertained that this pipe would not enter the well hole to a greater depth than 495 feet; we used the swedge with all the power available, but could not press out the double sheet iron 8-inch pipe, which was flattened at this point. It was a question whether we should cut away the portion of pipe intruding into the well by using the cutter and then the drills, and thus enlarge the well sufficiently, or employ a smaller diameter of pipe below this point, connecting it with 7-inch tubing by a reducer. We ascertained by impressions that there were other points below this one at which the sheet-iron casings had not maintained their circular shape, and that we might have to cut away the pipes in the well below this point at several places. It was therefore determined to pursue the latter expedient.

The size of this lower pipe was determined by the diameter of the barrel of the pump that would most probably be used in the well.

We were using a 2-inch pump at the time, but as in the future a 3 inch pump might be preferred, it was determined to employ 438 feet 4-inch diameter pipe in the lower portion of the well. This has been done, and the walls of the well are well protected by the outer double sheet-iron pipes of No. 20 iron, and by the inner wrought-iron pipe, with hermetically sealed joints, which extends from the bottom to top.

The lower 30 feet of the 4-inch pipe is perforated with holes to allow the water to enter it freely, and this pipe rests on the bottom of the well. The sheet-iron pipe at the bottom of the well was all broken and torn to threads by the explosion of the cartridge, and the water passes from the subterranean springs or stream directly into the wrought-iron pipe. As the water covers both sets of tubing at all times to within 15 feet of the top, there is no chance of oxidation of the metal composing the casings, and they will be preserved in their normal condition forever. A permanent supply of water is thus secured to the government for the boilers, for irrigation and for fire purposes.

I regret to report that the chemical analysis of the water proves that it is unhealthy for food for men or animals.

The water is clear, colorless, odorless, taste scarcely perceptible, but leaves a borax sensation on the tongue. It is very soft, of one-half the hardness of San Francisco drinking water. There is a large amount of vegetable matter suspended in it. The following results were obtained by analysis:

Parts in 1,000,000 of water.

Sodium, Na	345.76
Potassium, K	203.39
Calcium, Ca	21.10
Magnesium, Mg	7.78
Iron, Fe	.91

Sulphuric acid, S_2O_4	154.40
Carbonic acid, CO_3	203.22
Chlorine, Cl	425.30
Silica, S_iO_2	7.80
Organic matter	50.20
Total	1419.86
Total error	30.86
Total solid as	1389.00
Ammonia, free	2.03
Ammonia, albuminoid	1.15
Total ammonia	3.18

Albuminoid ammonia is derived from nitrogenous organic matter dissolved in the water, and indicates contamination.

Good drinking water should not contain more than .08 parts of it in 1,000,000 parts of water. Nitrogenous organic matter (generally of animal origin) is ten times the weight of the albuminoid ammonia.

In contrasting the water in the neighborhood with the artesian water at this post we find the following results:

Solid contents. Parts in 1,000,000.

Artesian water in San Francisco from about 350 feet depth	340
Artesian water in Contra Costa County, opposite Benicia, across the straits, same depth	324
As to hardness:	
San Francisco water	10.7°
Contra Costa water	20°
Benicia water	4.1°
As to albuminoid ammonia:	
San Francisco water	.11
Contra Costa water	.15
Benicia water	1.15

The amount of albuminoid ammonia in this water will preclude its use as food.

The only constituents that could render this water injurious for irrigation are the salt and soda it contains, and they do not occur in sufficient quantities to affect to any considerable extent the character of the soil.

All the tools have been removed from the tower and buildings at the artesian well, and I would suggest here, as it is pertinent, that these tools and rods, couplings, &c., are worth at least $2,000.

The sheds, lean-ups, and tank have all been cleared away; the tower has been strengthened and closed from the weather by siding, windows, and doors.

A windmill has been placed on top of it. The steam cylinder and boiler have been repaired, and arrangements made so that either wind or steam can be used for pumping water.

The well is now a permanent establishment of the post and furnishes water for the boilers at the shops, for irrigating the trees, and for watering the roads. If we had the reservoir, for which an estimate has been forwarded, on the hill to store this water we would have an abundant supply in case of fire.

ARRANGEMENTS FOR PROVING POWDER.

A suitable proving ground for large grained powder has been selected across the railroad track at Army Point on a line between stakes XXII and 131. (See skeleton map of Benicia Arsenal.)

The butt filled with sand for catching the shot has been erected near stake No. 131, and the 8-inch converted rifle-gun has been mounted to the east of stake marked XXII. The siege-gun will be placed near it.

From this point a range of 12 miles can be secured by firing up the Suisun Bay. An observation house to contain the chronoscopes and the electrical firing apparatus has been built on the brow of the hill, and to the east of main arsenal building. It is 52 feet above the gun and butt. The railroad track, the proving ground with all its apparatus, and the extreme range up the bay are included in the panoramic view which can be obtained from the floor of this house.

Near the large butt on the same platform the boiler-iron butt, the target, and camera house for small-arm firing will be placed, furnishing a range of 500 yards from the permanent rest in firing house on outer wharf. A firing gallery 120 feet long, with a room for chronoscope, has been built south of the office and parallel to it, for proving rifle-powder to be purchased on this coast.

APPENDIX 12.

REPORT OF THE PRINCIPAL OPERATIONS AT THE PICCATINNY POWDER DEPOT, NEW JERSEY, DURING THE FISCAL YEAR ENDED JUNE 30, 1882.

MAJ. F. H. PARKER, ORDNANCE DEPARTMENT, COMMANDING.

PICCATINNY POWDER DEPOT,
August 19, 1882.

The work that has been done in building up this post during the fiscal year is a continuation and prosecution of that which was begun last year and which was indicated to be done in my last annual report.

The appropriation being only $50,000, most of it was consumed in completing magazine No. 1, the remainder in clearing, draining, and improving grounds, making roads, erecting temporary building, and repairing old ones.

The condition of the magazine building on the 1st of July, 1881, was as follows: Most of the subfoundation had been laid, considerable stone had been cut, much of the building-stone from the quarry and all the iron-work, except the roof, was on hand.

A force of masons was put on the stone-work, and as soon as the foundation was up, what water-table was cut was laid and the brick-layers commenced their work. All the cutters who could be hired were taken on, and it was a race to keep ahead of the brick-work, the object being to finish the masonry and brick-laying before cold weather. This was accomplished and the building was ready for the roof by the middle of October. The roof, guttering, and leaders were finished by the 31st of December, and the floor and ceiling arches of hollow bricks should have been in according to agreement before cold weather, but the Fire-Proof Building Company of New York, who were to put them in, delayed commencing work until the 14th of December, 1881, and finished on the 7th of January, 1882. By keeping fires in the building the proper temperature for the work was maintained, and it was completed without injurious effects from the cold weather.

The interior wood-work was pushed as rapidly as possible, and the magazine was finished ready to store powder by the middle of February, 1882.

It is in plan, outside measurement, 205 by 52 feet. There are in it 21,782 cubic feet of rubble and scabled stone-work, 1,751 cubic feet of dimension stone dressed, consisting of water-table, pier-caps, sills, door-jambs, hinge-stones, beam and truss rests, 354,000 common bricks and 19,118 square feet of hollow brick arches, 195,000 pounds of iron, 12,369 square feet of corrugated iron roof, 1,021 barrels of cement and 300 barrels of lime; 2,220 feet of lightning conductors protect it, requiring deep wells and 1,006 feet of ditches for proper ground connections.

The price of labor and material was low, and every effort towards economy was made consistent with good construction. So far it appears to fulfill all anticipations as to strength, dryness, and light, and in this last respect far exceeds my expectations.

From experience so far, and from estimates of cost of different plans of construction, it is thought best to reproduce this plan in all respects except in the following minor details, viz: to have no cellar room; to reduce the thickness of the walls by one brick; to alter the construction of the iron doors and window shutters, and in placing the buildings hereafter to incline them more towards the north and south line to get greater benefit from the sun's rays on the west side in the winter. It is thought that these changes together with the greater facilities which time has given us will lessen the cost of the next magazine, notwithstanding the increase in cost of labor and material.

TEMPORARY BUILDINGS.

One of the principal difficulties connected with the work is the lack of lodging and boarding accommodations in the vicinity for a large force of workmen. To partly remedy this, two cheap frame buildings were erected, one consisting of mess-room, kitchen, and a few living rooms; the other, a dormitory or bunk-house, for the men. As it will only accommodate twenty-five or thirty men it will have to be enlarged this year.

Three of the old houses on the post have been repaired, and slight additions made to increase their lodging capacity. Another small set of frame quarters for the magazine keeper should be built as soon as possible.

The old stables have been repaired and altered to make them more convenient. New brick stables, in the proper location, and with necessary conveniences, are much needed.

GROUNDS AND ROADS.

Clearing land of brush and timber where required has progressed during the year. Through the winter a small force was kept on that work, and in the spring it was increased. About 40 acres have been cut out and about 17 acres grubbed, cleaned and put under cultivation. This already makes a change and improvement in the appearance of the valley. Grass was cut from the meadows, and the hay stored for public animals. The grain sowed was harvested and used for the same purpose, and a crop of oats and corn has been planted for this year's consumption.

About 10,000 feet of ditches have been dug to drain the land into the brook running through the grounds with marked improvement to that portion of them. The intention is to make these main ditches broad and deep, and where needed, afterward to underdrain into them by tile drain-pipe.

The old roads have been worked and improved, and the new East avenue, which is to run the whole length of the grounds on that side, and the extension of which leads to Dover and Port Oram, and will be the principal route of entrance and exit, has been made from the Middle Forge road to Mount Hope avenue, a distance of 3,300 feet. This involved considerable labor and expense, and was pushed to completion as rapidly as possible to give us access to the site of magazine No. 2, from the quarry and from all other parts of the tract. It is being carried on through the lower part of the grounds, also its extension to the Union turnpike. It was cut out and fenced last autumn and will be finished if possible this season.

These are the principal operations and work of this year; but in addition, numerous small jobs of improvement and arrangements to facilitate future work have been done.

For purpose of record and because it may be thought of interest to others to have this information, I herein give a general description of this new post, its location, and the proposed plans. I append the three accompanying maps, to assist in a clearer understanding of the brief descriptions; also add estimates of cost of construction and improvement. Most of this has heretofore been submitted to the department in different communications, but it is thought that it would not come amiss to have it in a condensed form.

This tract of land, which was selected for a powder depot from several others examined, mapped, and reported on, lies in the Middle Forge Valley, in Rockaway Township, Morris County, in the highlands of New Jersey, and is half-way between the Hudson and Delaware Rivers, on an east and west line drawn across the northern part of the State; its latitude being 40° 56½′ N.; longitude, 74° 33½′ W., and its elevation above mean tide-water 710 feet.

In going west from the Hudson River, the country is comparatively low and level until within 8 or 10 miles east of this place, its surface only being broken by the Bergen Hills, near the river, and the three Orange mountains of trap rock, and by hills and high planes of glacial drift. This section presents many natural advantages for the growth of beautiful towns and fine country residences, and it is more cultivated and thickly settled than the Highlands.

This latter section consists of a series of mountain ranges of granite, gneiss, conglomerate, sandstone, &c., running northeast and southwest, with narrow valleys between. There are many beautiful high-lying lakes, several of which are resorted to in summer on account of their beautiful scenery and cool air.

The slopes and the valleys are generally covered with layers of gravel and bowlders of varying thickness attributed to glacial action, the terminal moraine of which, running in an east and west direction, forms a line of hills across the valleys, which tends more or less to dam up the flow of the streams, draining them, and to render them wet and swampy. This is the case in the Middle Forge Valley. About a mile below the government line these hills cross the valley and turn off the Green Pond Brook towards the east, where, after forcing its way over a reef of bowlder drift and through old abandoned dams, it empties into the Rockaway River, below Port Oram. In consequence of these obstructions the stream in the lower part of the valley is sluggish, and overflows in the spring of the year that portion, as well as some part of the Powder Depot tract.

The mountain range in which this valley lies has different local names in its course from New Jersey to New England, and in it to the northeast is situated the Augusta tract, near the Erie Railroad, twice selected by boards of officers as a suitable site for a powder depot; also, the Sloatsburg, Queensboro, and Peekskill tracts. It is full of magnetic iron ore, the veins or deposits of which are inclosed in the masses of crystalline rocks of the range, and this place is the center of an extensive mining region. The hills on the east of the tract are called Mount Hope and Hickory Hill, and on the west the Green Pond Mountains, one peak of which is called Piccatinny, from which this depot was named. The hills on both sides are about 300 feet higher than the valley. The government tract consists of 3 miles in length of this narrow valley, and most of the mountain slopes on each side. The Green Pond Mountain sides are steep, and in some places precipitous, while the east side slopes are more gentle, with several natural terraces or benches nearly level.

The surface shows on the slopes and at the bottom of the hills a great accumulation of bowlders and stones; then come gravel and sand knolls and flats with a thin soil, and in the middle, along the brook side, a strip of low marshy ground. There is a small hill of limestone, which has been quite extensively used for making lime and for furnishing material for the iron furnaces at Mount Hope mines, about a mile distant. Second growth timber of chestnut, oak, hickory, &c., thickly cover a great part of the land.

From the lower line up to the pond, a distance of one and a half miles, the valley is 1,000 yards wide. There Piccatinny juts out and the mountain running straight for a mile and a half with an almost vertical face narrows the upper part to half that width. At the head of the valley is Copperas Mountain, to the foot of which the tract extends. On the east side of this mountain is Denmark Pond, and on the west side, lying at 1,069 feet elevation, is Green Lake or pond. From each of these waters a brook runs, uniting to form the brook running through the valley. The fall from Denmark Pond to Piccatinny Pond is 118 feet and from Green Lake 354 feet.

Piccatinny Pond gives a fall of 13 feet, with usually plenty of water. Its location, however, is not suitable for a powder mill, but can be utilized for much useful work. If thought best the pond could be entirely drawn off, making more available ground in the upper valley for powder mills.

This pond was first created and a forge set up for the manufacture of iron in 1749 or 1750 and is one of many that were in that early day in operation in these mountains. During the war for independence it was worked for the benefit of the American army in connection with the Mount Hope mines and furnace.

It is seen that the valley is inclosed with mountains except at its lower end, and is as well protected and isolated as any tract that could have been found. It is also protected from the northerly winds in winter, while the southerly winds seem to be drawn in all the seasons. The climate is characteristic of a high-lying valley in a mountainous region. The mean temperature is lower than that of Newark or New York. The frosts and snows come earlier and stay later, but the extreme of cold is but little greater than in the low country. The summers are comfortable and the nights remarkably cool. The rainfall is less than in the lower section east and the soil is non-retentive of water. The marshy land is an exception and should be reclaimed; clearing the land and draining the low ground will produce a drier and warmer atmosphere better suited to powder storage.

The requirements of a suitable site for a large powder depot, with government powder mills, have been formulated as follows:

1st. That it should be in a region of country which does not admit of being thickly populated, so that destruction of life and property in the case of accident would be a minimum.

2d. It should be sufficient in extent to contain suitable positions for magazines for storage of 10,000 tons of powder and material for its manufacture, as well as the necessary buildings for a government powder factory.

3d. It should be near enough to railroad and water communication to afford facilities for transportation to and from the seaboard, the interior and the lakes, having a short line of railroad connecting the site with trunk lines.

How completely this site fills these requirements can easily be judged. In the topographical characteristics of the tract itself, it also has its advantages and its disadvantages.

The natural features of the place plainly indicate the general arrangement and location of the buildings for different purposes and the roads and avenues necessary for proper communication and service.

The lower portion of the tract lying below the road that crosses the valley from Mount Hope to Berkshire is reserved for quarters, office, stables, barracks, &c. All above is shut off from the public, and that part lying between that road and the pond is reserved for the magazines, and all that from the lower end of the pond up is for the manufactory.

Only a general idea of the arrangements for the latter has as yet been fixed upon, and is indicated in as general a way on the maps.

Much depends upon the power employed. With the railroad to furnish coal, steam power could be used in whole or in part. There are many places well adapted as sites for the incorporating mills and the other small buldings containing the machines, &c., operating in the process of powder-making.

By setting up small engines at these different points, they could be utilized better than would be possible if confined to the line of water-power, which power would be variable in its supply, and might not be sufficient for all purposes. Probably it would be best to use both water and steam, as is done at many powder factories both here and abroad.

As far as the water-power is concerned, it is understood that 20 horse-power will be sufficient for two sets of wheels of size and weight as great as would be wanted running at a sufficiently high speed. With a fall of 10 feet, 24 cubic feet of water per second will be enough to give that amount of power. From the point where the streams unite to the pond, there is a fall of 40 feet, and it is probable that the above amount of water could be accumulated at three points in that distance with that much fall. The distance being 3,000 feet, the mills could be placed a safe distance apart, using the water over and over. What other convenient arrangements could be made to transmit the power to each side by wire ropes, and what capacity the water-power would develop, will have to be determined by an experienced hydraulic engineer. The long disused but valuable power at Denmark dam should be bought, which would add greatly to the value of the site.

The plans for the storage part of the depot contemplate the building of ten large magazines capable of storing 5,000 tons of powder and material; a coopering and packing house; two small storehouses for tools, implements, and stores; a set of officers' quarters; an office building; quarters for enlisted and hired men; stables for 12 horses and mules; a small guardhouse—all to be built of brick with stone foundations and trimmings; also the building or assisting in building of a branch railroad from Port Oram, where it would connect with the Morris Canal, the Delaware, Lackawanna and Western Railroad, and the Central Railroad of New Jersey, giving transportation in all directions. Miles of wagon-road will have to be built and acres of land cleared, drained, and graded. A level rifle range of 2,200 yards in extent, and a proof ground for testing powder in light and heavy guns, can be made at little expense, the firing being into the face of Piccatinny Mountain.

It would also appear that the natural and proper place for making cannon cartridges, large and small, and packing them for transportation, is at the powder depot; both safety and convenience suggest it. The powder and storage will be there, and the facilities can very readily be made. The filling and packing house would be put in a safe and convenient place behind Limestone Hill. The water-power at the pond is ample for the few wood-working machines necessary for the making of packing boxes and barrels, also for a few metal-working machines for a repair shop. From the magazines here, the boxes and barrels of cartridges can be shipped to the forts, the batteries, or arsenals, as required.

In estimating the cost of all the work of the storage part of the depot, we have the benefit of our experience as far as we have gone in this undertaking. There are, nevertheless, many elements of uncertainty, and this can only be regarded as an approximate estimate.

The plans of the buildings have been made and estimates of their cost have been furnished by an architect.

The cost of the branch railroad was estimated by the engineer who located the line:

Examination and surveys in selecting site and for legal expenses of purchase	$7,000
Land (1,866$\frac{13}{100}$ acres)	62,750
Ten large fire-proof magazines (brick)	500,000
A coopering, packing, and filling house (brick)	1,500
Two small tool and store houses (brick)	5,000
One set of officers' quarters (brick)	15,000
Quarters for enlisted and hired men (brick)	10,000
Office building (brick)	5,000
Guard-house (brick)	1,500
Stables (brick)	5,500
Two frame dwelling houses for master mechanic and magazine keeper	4,000
Six miles of road	26,400
Ditching and underdraining and filling grounds	25,430
Clearing, grubbing, grading, and cultivating 335 acres of woodland	18,750
Straightening, diking, and cleaning brook where needed	32,850
Stone wall and fences along public road, &c	14,320
Branch railroad into tract ($47,400); cost to government, say	25,000
	760,000
Deduct $225,000 already appropriated	225,000
Balance required	535,000

The estimate for the shop, necessary tools and machinery, a new masonry dam, &c., is not included.

It is thought that this place presents some attractive natural advantages for the development of a convenient, creditable, and much-needed powder establishment of this kind. Its importance has been repeatedly set forth in annual ordnance reports, and in communications from experienced officers. It cannot be denied that nothing can be of greater importance to the military and naval service than a wise provision for a plentiful supply of that material which is the very pabulum of war, and without which successful war is impossible. It has been pointed out that we are behind other nations in this respect, and that our method of securing a supply of powder has heretofore been more successful than it is likely to be in the future, for the reason that it is only within the last few years that the facts pertaining to and the laws governing the explosion of gunpowder, which scientific investigation has disclosed, have been put into practical application, resulting in a much greater variety of powders, needed and requiring more time, skill, and expense in their production.

The annual manufacturing capacity of the Waltham Abbey Mills is given as 14,000 barrels of that kind of powder which requires the most working. There are thirty-two incorporating mills at those works which give 437½ barrels per mill per year. It is believed that neither hexagonal nor prismatic powder could be produced at as rapid a rate; that they require to be longer in the mill, and that the other processes need more time and care; also that the government would find difficulty in commanding throughout the whole country the above number of mills which could be spared to run on powder for heavy guns alone.

If this is so it will be seen that the command of a large plant would be required in case of emergency for supplying the wants of an armament, for our seacoast and ships, of modern heavy ordnance, the charges of which consume from two to five barrels for each shot fired. In addition there would be wanted a supply for siege and field artillery, and for small arms. It is, therefore, necessary to accumulate a considerable quantity of these different kinds of gunpowders in magazines suitable for storage.

The establishment of government experimental powder mills, so long regarded as of vital importance, to enable us by investigation and experiment to keep pace with other nations in powder improvements, has now a beginning, so far as securing a site is concerned which is more or less suitable, and it would seem to be advisable to prosecute its building up along with the storage part of the depot.

APPENDIX 13.[*]

REPORT OF THE PRINCIPAL OPERATIONS AT THE FRANKFORD ARSENAL, PENNSYLVANIA, DURING THE FISCAL YEAR ENDED JUNE 30, 1882.

MAJ. S. C. LYFORD, ORDNANCE DEPARTMENT, COMMANDING.

(Seven plates.)

THE GILL DYNAMOMETER. (Plate I.)

In connection with the inclosed drawings the following directions for the use of the instrument are respectfully submitted:

This instrument consists essentially of a hydraulic jack for producing pressure, and a system of levers and weights for recording them.

There are two distinct methods of applying the pressure; one by hand, the other by the accumulator. Both methods involve the use of the jack; but in the first the pressure is intermittent, while in the second it is continuous.

Automatic checks are arranged so as to relieve the pressure where the required effect has been produced.

The combination leverage is 1 to 200. The capacity of machine is 10,000 pounds, and any pressure up to that limit can be measured by the proper adjustment of the weights in the scale-pan and the slide on the graduate levers.

The principle and construction of the instrument can be best shown by giving detailed directions for its use. The plate is sufficiently explained by the references.

TO USE THE MACHINE BY HAND.

1. Weight the scale pan and adjust the slide S and weight *w* according to the pressure required.
2. Turn the automatic check lever to the left, so that it will be held in position by allowing the lever L to rest on the arm *a*.
3. Turn up the weight *u*—which works the release valve—until it is caught and held in position by the arm *b*.
4. Turn the starting lever up until it strikes its stop in the position shown at *c*.
5. Adjust the copper disk under piston of the jack, allowing the knife to touch it as lightly as possible.
6. Attach the pump lever to the stud *d* and work it with a strong, steady pull.

When the indicated pressure has been applied the scale-pan will be lifted, allowing the automatic check lever to fall. The arm *b* is thus drawn to the left sufficiently to release the weight *u*, and the latter in its fall opens the release valve. This affords a passage from the pump into the fluid chamber and relieves the piston from pressure. The return weight W then runs the piston up and releases the copper disk.

When the pressure to be applied is equal to that of the accumulator weights the accumulator must be shut off by running in the screw *e*.

TO USE THE ACCUMULATOR.

Turn the starting lever down and the release valve weight up.

Run the accumulator weight up by means of the pump.

Then follow directions 1, 2, 3, 4, and 5, in the instructions for use by hand.

To apply the pressure, turn the lever *f* to the left until the arm *g* is caught and held by the latch *h*, as shown at *h* in the plate.

When the indicated pressure is produced the fall of the automatic check lever lifts the latch *h* and allows the weight *m* to fall, closing the accumulator valve and preventing the fluid from entering the jack.

The weight *n* also falls and opens the release valve so that the piston can be run up by the return weight, as before.

PLATE II.

Plate II shows the relations between certain pressures and the corresponding cuts, together with similar data obtained from the Watertown Arsenal testing-machine. The copper used was all from one lot, and consisted of bars of rectangular cross-section, carefully treated so as to obtain, as nearly as possible, a uniform density of hardness.

By reference to the plate it will be seen that the two machines give practically the same results.

The above-described instrument, though simple in construction and easily understood, requires very careful manipulation in order to obtain reliable results. The effect of time, as an element in its operation, must be thoroughly understood so that the various results may be intelligently compared, and that they may subserve the purpose for which they are obtained.

INSTRUMENTS, TOOLS, &c.

PADDOCK'S INTERPOLATOR. (Plate III.)

This instrument for pointing mortars was completed and issued during the year, and the inclosed drawing illustrates its construction. Nothing has yet been heard of its practical use, but it is presumed it answers the purpose for which it was intended.

STAR GAUGE, MODEL 1881. (Plate IV.)

This instrument has been completed and is ready for use. It embodies several special features:

1. A vernier, reading diameters to $\frac{1}{1000}$ inch from 12 to 42 inches.
2. Appliances for sustaining and moving the instrument concentrically along the bores of guns and tubes.
3. A caliper, for adjusting the points and vernier to various diameters, thus dispensing with the rings formerly used.

Drawings illustrating the instrument and its parts are inclosed. As it has not yet been tested up to its full capacity, no opinion as to its success can now be formed, although it is believed it will meet all requirements.

SHOT-GUN OUTFITS.

Three hundred and two sets of special tools for reloading shot-gun shells, and outfits containing these with material for about 500 rounds of ammunition, have been prepared during the year.

Drawings are inclosed showing:

1. The set of tools. (Plate V.)
2. The field case. (Plate VI.)
3. The packing of the outfit. (Plate VII.)

The field case enables an ample supply for a hunting expedition to be carried in a compact form.

Among the tools, attention is invited to the (1) priming tools designed here, which can be adapted to all sizes of shells having a central vent in the primer pocket; (2) the powder and shot charger which is adjustable for charges of either within the extreme limits of light charges for gallery practice and heavy charges for killing game.

During the months of September and October exhaustive tests were made of the Hotchkiss patent cartridge case, using the Frankford Arsenal solid head for comparison with it. These cases were loaded both by the hand and bench reloading tools, using for the charge 70 grains of Du Pont powder and the 405 grain bullet. Over 1,000 rounds were fired of each, the shells being reloaded and fired to extremity. The following is a summary of the results of these experiments:

Average force of extraction of Hotchkiss cases:		
Annealed after last draw:		
Before reloading	pounds	18.4
After reloading	do	2.4
Annealed previous to last draw:		
Before reloading	do	2.35
After reloading	do	2.07
Annealed previous to last three draws:		
Before reloading	do	1.5
After reloading	do	1.48
Average force of extraction of Frankford Arsenal cases:		
Annealed previous to last 3 draws, usual method of manufacture:		
Before reloading	do	.91
After reloading	do	.92
Average life of Hotchkiss cases:		
Annealed after last draw	rounds	25.35
Annealed previous to last draw	do	40.05
Annealed previous to last 3 draws	do	50.5
Average life of Frankford Arsenal cases:		
Usual method of manufacture	do	33.56
Cases split:		
Hotchkiss	number	31
Frankford Arsenal	do	58
Cases disabled by bursting, &c.:		
Hotchkiss	do	27
Frankford Arsenal	do	0
Percentage of leaks:		
Hotchkiss		37
Frankford Arsenal		8

In Major Lyford's indorsement of October 12, 1881, submitting the results of this trial, the following remarks were made:

> The bad extraction in the first manufacture was clearly due to faulty manufacture, and I see no reason why the case cannot be made to extract as easily as any other, as is indicated by the subsequent trials.
>
> It is probable that a smaller primer, by decreasing the size of the pocket or hole in the head, would obviate the leakage around it, and perhaps correct the tendency of this hole to enlarge.

In October tests were made for endurance and extraction of the Frankford Arsenal shot-gun shell, using the Winchester shot-gun shells for comparison. Five shells of each were fired 100 times, the charge being 75 grains powder and $1\frac{1}{8}$ ounces No. 6 shot, and these showed an average extraction of less than $\frac{7}{10}$ of a pound for the Frankford Arsenal shell, and an average of more than 9 pounds for the Winchester. One of each of these shells was then fired 150 additional times, with an average extraction about the same as the above, both of the shells being in as good a condition at the end of the 250th round as when first fired.

During this month we made several tests of Du Pont's strong sporting powder in comparison with our service powder, with the view of obtaining, with a small charge, the same results we now obtain, and thus make a shorter cartridge for use with a magazine arm, and while the results were to a certain extent satisfactory, still we found that with their strongest powder we could not diminish the charge more than sufficient to shorten the length of the cartridge 5½ per cent.

In this same month a few tests were made of carbine and rifle ammunition in the two arms, to determine their relative merits, the results of which were summed up as follows:

Arm and ammunition.	Accuracy at 500 yards. Circle of shots in feet.	Sight used for 500-yard target effecting the dangerous spaces.	Velocities.
		Yards.	
Rifle with rifle ammunition	.62	450	1332
Carbine with rifle ammunition	.68	500	1279
Carbine with carbine ammunition	.93	550	1129

In November, experiments were made to determine the cause of the rupture of the service cartridge in the chamber of the rifle, and after many preliminary trials we were finally able to so lubricate the cartridge, made prior to 1876, that we could rupture it almost at will; the conclusion we drew being that the cause of the rupture of the shell is the checking of the free forward flow of the fluid occupying the space between the case and the walls of the chamber of the rifle. This, by its reflex action, acts like a blow on the outside of the case, immediately after the inside has been suddenly strained by the gases generated within, and the case, if not strong enough, yields to the blow, and is broken in two—not pulled apart. This separation takes place before the front part of the shell is free of the bullet, and hence it is dragged some distance into the rifling.

In the tests where the cases were filed nearly in two, nothing being used to prevent the free flow of the intervening fluid, it was noticed that the front of the shell was acted on by the ball in the same manner as in the ruptured cases, but that there was a *free escape of gas*, while in the other tests no trace of the gas was visible; showing that at the time of rupture the external force was equal to or greater than that generated within. Since May, 1875, the walls of the service cartridges have been frequently strengthened, and as we were not able, under any circumstances, to rupture these cartridges, we inferred that none would hereafter ever be ruptured in service, no matter how lubricated.

During December, 1881, and January, 1882, very extensive experiments were undertaken to determine why our velocities obtained in summer were so much higher than those obtained in winter, when the same charge was used, the only seeming variable being the difference in temperature of the atmosphere. Some 333 velocities were taken, with the cartridge and rifle both warm and cold, the air through which the bullet passed being about the same temperature. With the cartridges and rifle warmed by a temperature equal to that obtained in summer, and cleaned between each shot, our velocities were 1,356 feet; and with cartridges and rifle cold at a temperature of 32 degrees, the cartridges being kept at that temperature long enough to insure the powder in the case having that degree of heat only, gun not cleaned between shots, we obtained only 1,295 feet velocity; a difference of some 61 feet.

We also found that the pressures under these different circumstances varied between 29,300 pounds when warm to 25,050 pounds when cold, and the fouling varied from 7.6 grains with cold gun and cartridge to 5.4 grains with warm gun and cartridge; our conclusion from these experiments being that the effects of heat upon both the cartridge and rifle are to decrease the amount of the fouling and increase the pressure of the gases and the resulting velocities; also, that the temperature of the air through which the bullet passes has very little effect upon the velocities, and that care should always be taken to have cartridges and rifle at a uniform temperature when taking velocities.

During January, 1882, 750 primers, a sample of those furnished by the Winchester Company, were tested for piercing; out of this number some 46 were pierced by the firing pin.

During this same month some Lowell contract ammunition, manufactured in 1874, 1875, and 1876, now on hand at this arsenal, was thoroughly tested, to see if it would be suitable for issue for target practice, but from the defects shown during these firings it was deemed advisable to not issue it.

In February 3,200 primers, a sample of those furnished by the Winchester Company on contract, were tested, and during the same month 2,000 of those manufactured at this arsenal. To fill an order for supplies calling for cartridges for experimental purposes with the 500-grain bullet, giving velocities of 1,250, 1,200, 1,100, 1,000, 900, 800, 700, 600, 500, and 400 feet velocity, we, during the month of May, experimented as to the proper charge of powder to be given them to obtain these results, the powder having a uniform compression. Over 100 velocities were taken to obtain these results, which may be summed up as follows:

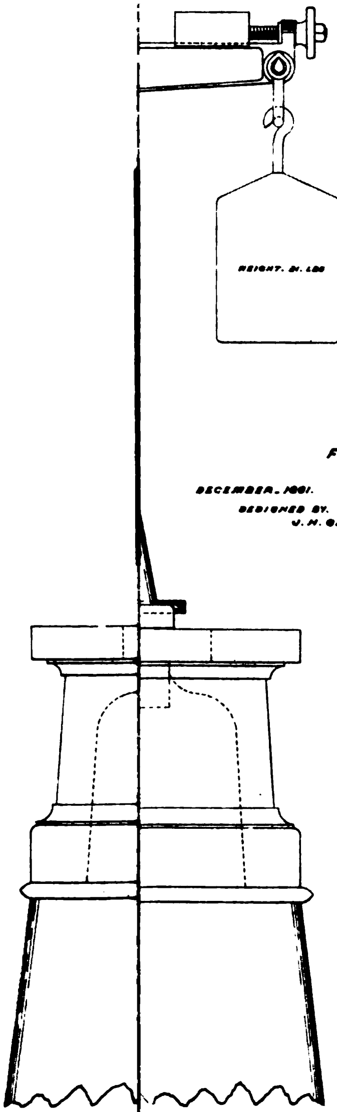
Charges of powder, &c., required with the Frankford Arsenal solid-head reloading case and 500-grain bullet, model 1881, to obtain the prescribed velocities.

Velocities.	Powder, Du Pont's.	Strawboard wads between powder and bullet.
Feet.	*Grains.*	*No. of.*
1,250	69	0
1,200	63	0
1,100	55	3
1,000	46	6
900	40	10
800	32	14
700	25	18
600	18	20
500	14	23
400	11	25

During June very extensive experiments were made of cartridge primers to determine the proper thickness of metal to make them of, so as to insure certainty of fire, and prevent piercing by the firing pins.

Six thousand were used with the Springfield rifle, using 70 grains of powder and 405-grain bullet for a charge, and 6,000 in the same rifle with a charge of 70 grains of powder and 500-grain bullet. The same number of each kind of charge were used with the Gatling gun, and 3,000 in the Smith & Wesson revolver, and 3,000 in Colt's revolver, using primers of .023, .024, .025, .026, .027, and .028 inch thickness; and while these results showed that the primer should not be less than .025 inch in thickness, still it was thought best to obtain metal of other manufacture (the above having been furnished by the Waterbury Brass Company), and continue this experiment the next fiscal year.

PLATE I.



DYNAMOMETER.

FOR GUN PRESSURES.

DECEMBER, 1881.
DESIGNED BY.
J. H. GILL

PLATE III.

LIEUTENANT PADDOCKS' INTERPOLATOR

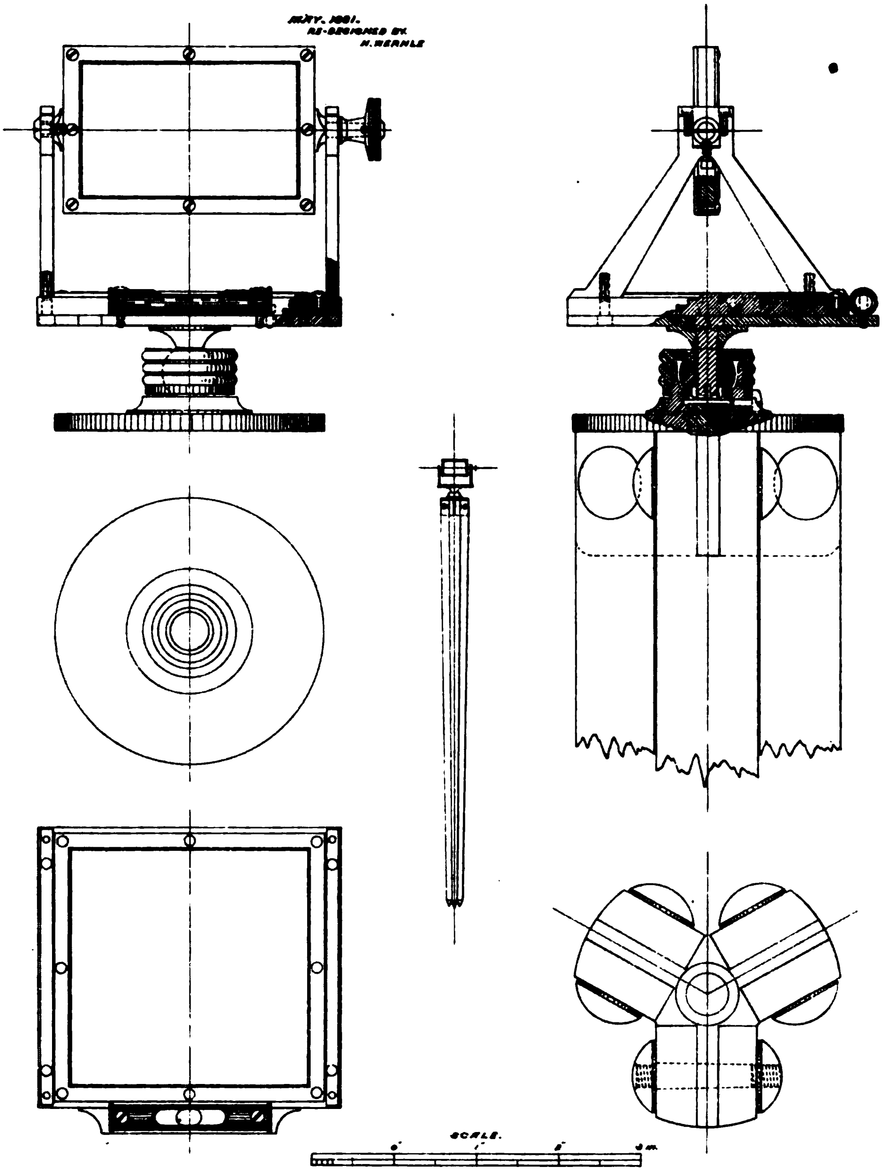


PLATE IV.

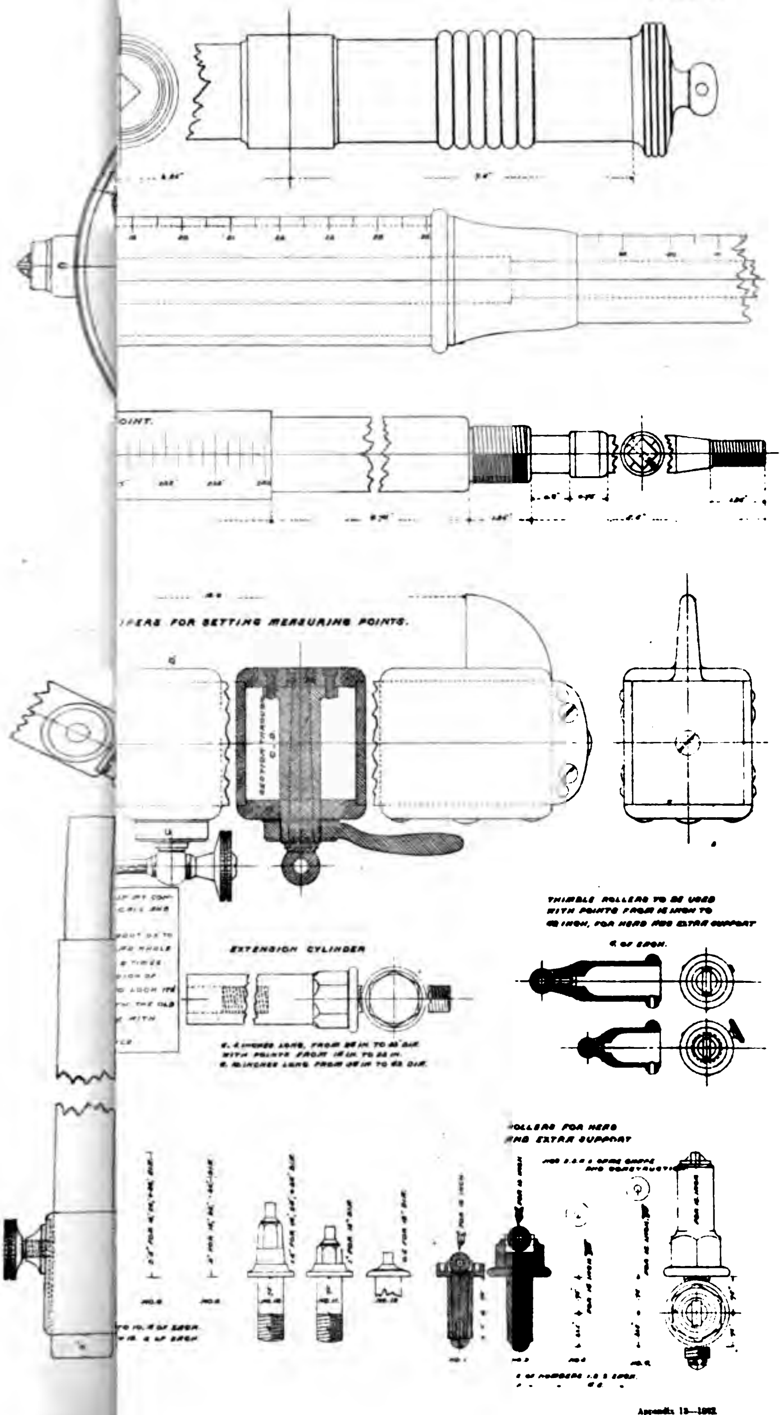
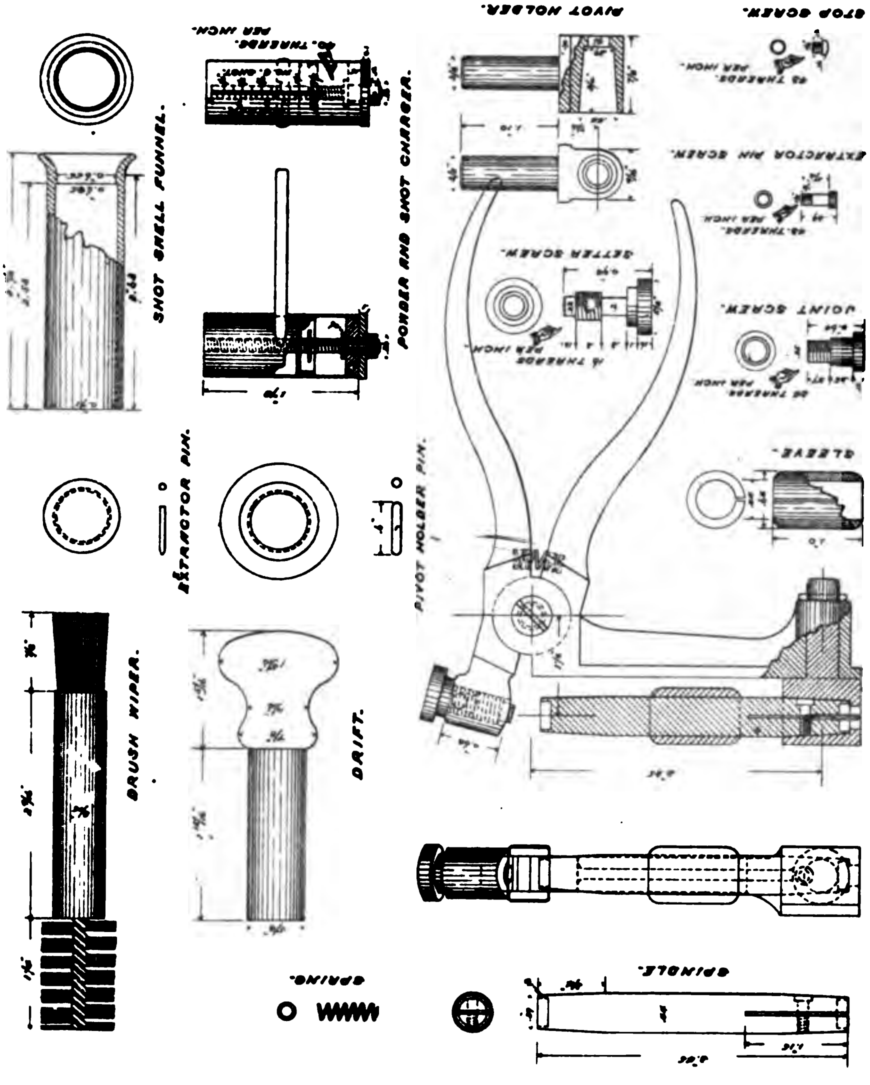

OINT.
PERS FOR SETTING MEASURING POINTS.
SECTION THROUGH C. D.
EXTENSION CYLINDER
THIMBLE ROLLERS TO BE USED
WITH POINTS FROM 16 INCH TO
68 INCH, FOR HEAD AND EXTRA SUPPORT
OLLERS FOR HEAD
AND EXTRA SUPPORT
AND CONSTRUCTI

PLATE V.

SHOT SHELL RELOADING TOOLS.



FIELD CASE.

FOR

SHOT GUN OUTFIT.

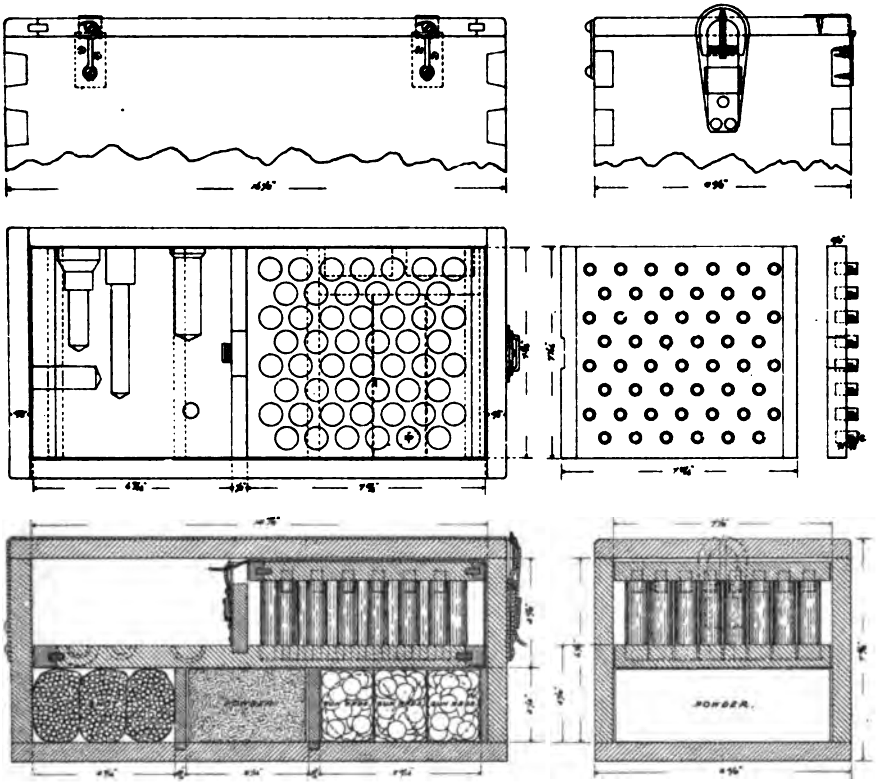
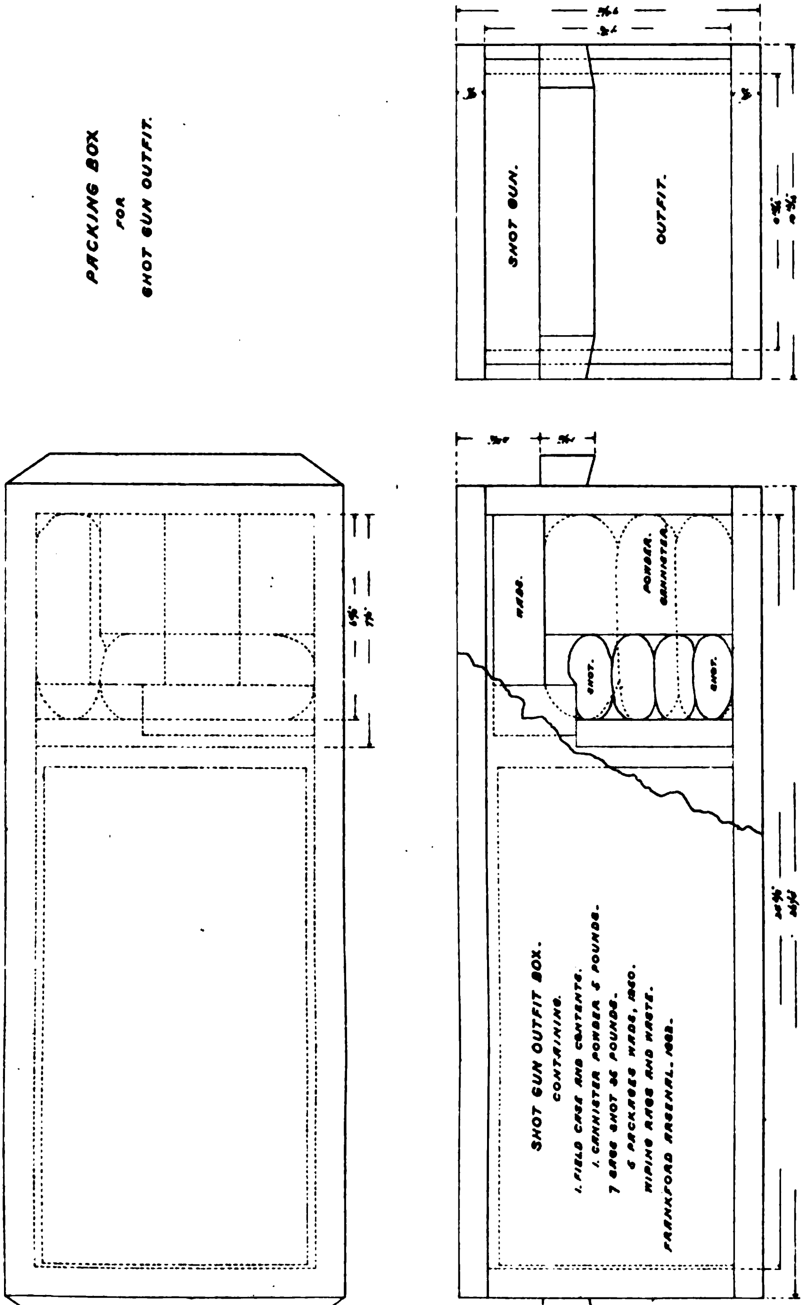


PLATE VII.

PACKING BOX
FOR
SHOT GUN OUTFIT.



Appendix 13—1882.

APPENDIX 16.

PROOF REPORT, &c., OF 8-INCH BREECH-LOADING RIFLE NO. 5.

(One plate.)

NEW YORK CITY, *December* 12, 1881.

SIR: I have the honor to forward herewith Captain Starring's firing report, in the proof of 8-inch breech-loading rifle No. 5, which was ruptured, with the opinions of certain steel experts on the quality of the metal in the breech-receiver; also certain data pertaining to the gun and its proof, and the records of tests made of the metal in the breech-receiver (Appendices I, II, and III), which have been prepared at this office.

It is not believed that much weight should be attached to the opinions of Messrs. McLaughlin and Corbett, as they made no tests of the steel, and their experience has chiefly been confined to steel in small masses and of such quality as is employed in cutlery. I also inclose a duplicate of these papers, together with an additional number of records of tests made of the Firth's steel employed in the 8-inch and 11-inch breech-loading rifles, to enable you, should you so desire, to furnish the information to the Board on Examination of Heavy Ordnance and Projectiles.

Very respectfully, your obedient servant,

CHAS. S. SMITH,
Capt. of Ord., Asst. to Constructor of Ord.

The CHIEF OF ORDNANCE, U. S. A.,
Washington, D. C.

APPENDIX I.

EIGHT-INCH BREECH-LOADING CHAMBERED RIFLE NO. 5.

(1.) Area of bottom of bore, subjected to pressure	square inches	88.23
(2.) Area of walls of breech slot in plane of front face of breech block	do	148.28
(3.) Total area of fracture in walls of breech receiver	do	192.05
Ratio of (1) to (2)		1.685
Ratio of (1) to (3)		2.17
Ratio of (2) to (3)		1.29
Highest pressure per square inch endured by gun	pounds	38,000
Pressure per square inch at rupture	do	38,000
Ultimate resistance per square inch of steel in breech receiver	do	94,500
Total pressure on bottom of bore	do	3,352,740
Total resistance of metal in walls of breech slot, section (2)	do	14,012,460
Total resistance of metal in walls of breech slot, section (3)	do	18,148,725

This gun underwent longitudinal rupture in the breech receiver, in front of the breech block, at the third round. For position and direction of fracture, and details of powder-proof, see accompanying plate and firing record. Rupture commenced in the left-hand upper front angle of the breech slot, and progressed, apparently, about half-way round the bore, when the metal gave way in the left-hand *lower* front angle of the breech slot, the two movements being superposed over a distance of about 8 inches, thus causing a complete detachment of the interlying metal that separated the two courses of fracture. The lower and front angles of the breech slot were square, whilst in the first 8-inch breech-loading rifle they were filleted with a radius of 0.35-inch.

APPENDIX II.

The pressure indicated by the Rodman gauge at the round in which rupture took place in 8-inch breech-loading rifle No. 5 was very high—over 70,000 pounds; but the bottom of the housing of the gauge gave evidence, in a heavy bruise, of having come in violent contact with some hard and resistant object. To the latter fact must be attributed the abnormal pressure indicated, since, with the same kind and weight of powder and projectile, and fired on the same day from 8-inch breech-loading rifle No. 2, the pressure indicated in the latter was 38,000 pounds per square inch—a result that has since been confirmed by more numerous firings as amply high. To ascertain the precise effect of a heavy blow on the bottom of the pressure gauge, a series of experiments were made by allowing the gauge to drop from a fixed height upon a bed both of hard and of a soft material. The results were as follows:

Experiments at Sandy Hook, October 28, 1881, in allowing the Rodman pressure gauge to fall freely from balcony of Western Union tower upon a stone placed at foot of tower.

Height of balcony	feet	61.75
Velocity of fall	do	63.
First trial:		
Length of cut	inch	0.96
Corresponding pressure	pounds	46,000
Second trial:		
Length of cut	inch	0.895
Corresponding pressure	pounds	35,500

Two more experiments were made, allowing the gauge to fall from same height as in previous experiments into soft sand, but no appreciable cut was obtained.

	Grains.
Weight of gauge used, complete with discs	36,620
Weight of knife and piston	1,875
Weight of first disc used	1,505
Weight of second disc used	1,525

Plug used, marked "Frankford Arsenal 1880, No. 3."

Target record of firing with 8-inch breech-loading chambered rifle No. 5, at Sandy Hook, N. J., October 1, 1881.

[Gun mounted on cradle; fired into sand butt No. 2.]

Number of fire.	Time.	Powder.		Projectile.		Elevation in degrees.	Pressure, pounds per square inch of bore.	Remarks.
		Kind.	Weight.	Kind.	Weight.			
	1881.		*Pounds.*		*Pounds.*			
1	Oct. 1	F. P. D., No. 9.	50	Hotchkiss re-saboted dia. band 8.17	179	0	29, 500	Gun closed and opened easily by one man; no escape of gas.
2	Oct. 1	....do	55	....do	179	0	32, 500	Do.
3	Oct. 1	I. O. A., No. 6.	50	....do	179	0	....	Breech block and receiver parted from gun (fracture in thickest part of steel receiver), being thrown nearly direct to the rear for a distance of 377 feet; 80 feet from gun broke hydraulic jack on sling-wagon; 170 feet struck and tore up plank road; 260 feet struck sand; 285 feet struck and destroyed corner post, porch of shop; 292 feet broke traverse wheel leaning against corner of shop; 307 feet struck sand; 362 feet destroyed platform over well; 377 feet came to rest 1 foot from door of engine-room of shop.

Accompanying this report are three photographs showing fracture. Also letter containing opinion of J. McLaughlin and Thomas H. Corbett as experts with reference to the steel of the breech receiver. Five specimens of steel (three short and two long) cut from breech receiver and sent to Captain Smith, United States Ordnance Agency, for test.

W. S. STARRING,
Captain of Ordnance, in charge of firing ground.

NEW YORK, *October* 7, 1881.

DEAR SIR: At the request of Mr. A. G. Sinclair, I went to Sandy Hook with Mr. Thos. Corbett, to inspect the gun that did not stand your test.

After a careful examination of the fracture, I am convinced that the original bloom or cast was imperfect. There are three places in the fracture that do not show any fiber, equal to about one-third of the whole surface of the break, which is a peculiar one, as it gave way where there was the largest amount of metal instead of the least, which is usually the case. I have been working steel for over thirty years, and have no hesitation in saying it is a very imperfect piece of metal.

Respectfully, yours,

J. McLAUGHLIN,
THOS. H. CORBETT.

Captain STARRING.

Star gauging of 8-inch breech-loading chambered rifle No. 5.

Inches from muzzle.	October 1, 1881, original diameter of bore.	October 21, 1881, diameter after three rounds.	Inches from muzzle.	October 1, 1881, original diameter of bore.	October 21, 1881, diameter after three rounds.	Inches from muzzle.	October 1, 1881, original diameter of bore.	October 21, 1881, diameter after three rounds.
94	7.996	8.015	70	7.998	8.009	34	8.000	8.000
93	7.996	8.014	68	7.998	8.012	32	8.000	8.000
92	7.996	8.010	66	7.998	8.010	30	8.000	8.000
91	7.996	8.009	64	7.998	8.007	28	8.000	8.000
90	7.996	8.006	62	7.998	8.006	26	8.000	8.000
89	7.996	8.006	60	8.000	8.005	24	8.000	8.000
88	7.996	8.006	58	8.000	8.005	22	8.000	8.000
87	7.996	8.006	56	8.000	8.006	20	8.000	8.001
86	7.996	8.009	54	8.000	8.006	18	8.000	8.001
85	7.996	8.011	52	8.000	8.005	16	8.000	8.001
84	7.997	8.013	50	8.000	8.004	14	8.000	8.001
83	7.999	8.014	48	8.000	8.003	12	8.000	8.001
82	8.000	8.014	46	8.000	8.003	10	8.000	8.001
81	8.000	8.014	44	8.000	8.002	8	8.000	8.001
80	8.001	8.014	42	8.000	8.002	6	8.000	8.001
78	8.001	8.009	40	8.000	8.002	4	8.000	8.001
76	8.000	8.007	38	8.000	8.001	2	8.000	8.001
74	7.999	8.006	36	8.000	8.001	1	8.000	8.001
72	7.998	8.004						

Inches from end of breech receiver.	October 1, 1881, original diameter of chamber.	October 21, 1881, diameter after three rounds.	Inches from end of breech receiver.	October 1, 1881, original diameter of chamber.	October 21, 1881, diameter after three rounds.	Inches from end of breech receiver.	October 1, 1881, original diameter of chamber.	October 21, 1881, diameter after three rounds.
26	9.004	9.042	33	9.000	9.015	39½	9.003	9.017
26½	9.004	9.041	33½	9.000	9.013	40	9.004	9.019
27	9.003	9.039	34	9.000	9.010	40½	9.005	9.019
27½	9.000	9.036	34½	9.000	9.009	41	9.006	9.019
28	9.000	9.033	35	9.000	9.009	41½	9.005	9.022
28½	9.000	9.032	35½	9.000	9.009	42	9.005	9.022
29	9.001	9.031	36	9.000	9.010	42½	9.004	9.020
29½	9.000	9.031	36½	9.000	9.010	43	9.003	9.020
30	9.000	9.030	37	9.000	9.010	43½	9.003	9.019
30½	9.000	9.027	37½	9.001	9.010	44	9.004	9.019
31	9.000	9.024	38	9.003	9.012	44½	9.004	9.018
31½	9.000	9.022	38½	9.003	9.015	45	9.002	9.018
32	9.000	9.019	39	9.003	9.017	45½	9.004	9.017
32½	9.000	9.018						

APPENDIX III.

Comparative qualities of oil-tempered steel.

Physical qualities.	Firth's steel, used in 8-inch breech-loading rifle No. 5 (ruptured).	Conditions of reception imposed by the English artillery for cannon.*	Conditions of reception imposed by the French Government.†		Firth's steel, from 2.95-inch field-guns (tested in France).*
			In the land service.	In the naval service. (Tubes and frettes.)	
Limit of elasticity	52,000	64,720 to 75,933	45,417 (breech). 49,675 (chase).	42,579	41,159 to 48,965
Ultimate resistance	94,500	89,415 to 129,582	87,996 (breech). 92,253 (chase).	85,158	74,513 to 83,029
Ultimate elongation	6.79 per cent.	2.5 per cent. to 15.2 per cent.	10 per cent. to 14 per cent.	5 per cent.	4.5 per cent. to 17 per cent.

* See Revue d'Artillerie, July, 1874, p. 321.

† See Aide Mémoire à l'Usage des Officiers d'Artillerie, 1880, pp. 63–65.

Firth's steel, used in 8-inch breech-loading rifle No. 5.

Average density	7.8574
Average tenacity	115,758 lbs.
Average hardness	20.92
Hardness of copper	5

Specimens, how taken.	Density.	Tenacity.
Tangentially	7.8561 7.8496	110,820 127,600
Radially	7.8603	115,265
Longitudinally	7.8610	109,840

FIRTH & SONS' STEEL FOR ARMY GUNS.

Results of tests by tensile strain on specimens cut from 5 8-inch jackets (furnished the South Boston Foundry).

MARCH 30, 1881.

Tests from jackets before oil tempering.			Tests from jackets after oil tempering.		
How treated.	Breaking strain per square inch.	Elongation.	How treated.	Breaking strain per square inch.	Elongation.
	Tons.	*Inch.*		*Tons.*	*Inch.*
S soft	31.95	0.59	OH′	40.72	0 46
L tempered	47.47	.38	OH″	40.72	.38
H tempered	48.15	.40	OH‴	40.72	.37
			OH′	33.30	.04
			OH″	44.77	.09
			OH‴	46.12	.11
S soft	32.28	.55	OH′	40.72	.28
L tempered	46.12	.36	OH″	42.07	.43
H tempered	46.12	.38	OH‴	40.05	.13
			OH′	37.35	.03
			OH″	49.16	.14
			OH‴	37.35	.04
S soft	32.28		OH′	41.73	.33
L tempered	45.45		OH″	41.40	.21
H tempered	46.46		OH‴	39.37	.39

FIRTH & SONS' STEEL FOR ARMY GUNS.

Results of tests by tensile strain, 5 8-inch slide bars (furnished South Boston Foundry).

Tests before oil tempering.			Tests after oil tempering.		
How treated.	Breaking strain per square inch.	Elongation.	How treated.	Breaking strain per square inch.	Elongation.
	Tons.	*Inch.*		*Tons.*	*Inch.*
S soft	32.96	0.48	OH′	39.71	0.24
L tempered	48.82	.31	OH″	42.07	.23
H tempered	48.82	.24	OH‴	41.06	.20
S soft	36.33	.17	OH′	37.68	.20
L tempered	57.26	.17	OH″	38.70	.22
H tempered	52.87	.09	OH‴	37.35	.27
S soft	Not sufficient material for testing before oil tempering.		OH′	53.21	.16
L tempered			OH″	55.23	.14
H tempered			OH‴	52.53	.14
S soft	do	do	OH′	32.96	.22
L tempered			OH″	30.60	.05
H tempered			OH‴	32.62	.31
S soft	34.65	.42	OH′	35.32	.36
L tempered	56.92	.09	OH″	37.35	.23
H tempered	54.22	.16	OH‴	36.67	.33

FIRTH & SONS' STEEL FOR ARMY GUNS.

11-inch jacket and slide bar (furnished to the South Boston Iron Foundry).

APRIL 7, 1881.

Mark and number.	Description.	How treated.	Breaking strain per square inch.	Elongation.	Remarks.
			Tons.	*Inch.*	
P. K. & Co	Jacket	S soft	27.90	0.55	Full fiber.
Number 6	do	L tempered	42.07	.40	
Do	do	H tempered	40.72	.42	
P. K. & Co	Slide bar	S soft	32.96	.54	Full fiber.
Number 6	do	L tempered	51.86	.16	Fine grain.
Do	do	H tempered	54.22	.22	Fine with fiber.

REFERENCE TO THE MARKS, &C., SHOWN ON OUR TEST REPORTS.

S. Soft. Test made from disc cut from forging previous to its being turned or tempered in oil, and tested in the soft state.

L. Tempered. Test made from disc cut from forging previous to its being turned or tempered in oil, and turned to the size shown on diagram (.658 inch) then tempered in oil at a *low cherry red heat*, and afterwards turned to the proper size (.533 inch) and tested.

H. Tempered. Do. but tempered in oil at a *high cherry red heat*, and afterwards turned to the proper size (.533 inch) and tested.

OH. • Oil tempered. } Tests made from disc cut from forging after it has been rough finished, tempered in oil.
• • “
∴ “

The dots merely denote the number (1, 2, and 3) of specimens tested.

NORFOLK WORKS,
Sheffield, June 2, 1881.

DIAGRAM OF TESTING PIECE FOR TENSILE STRAIN.

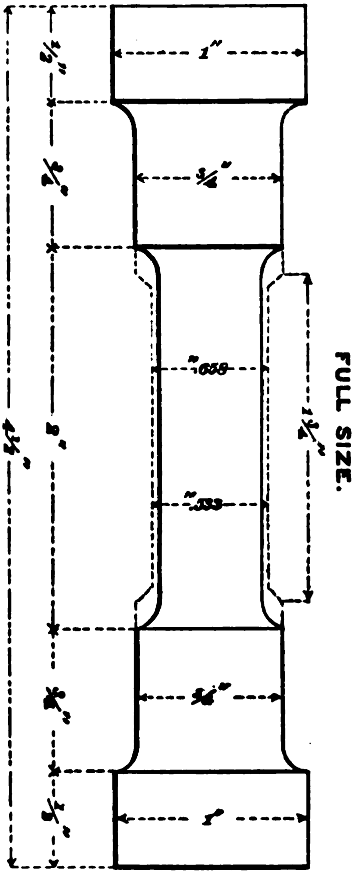
[Full lines show finished sizes. Dotted lines show the amount left on the specimens previously to its being tempered or hardened in oil. The strains are calculated on the primary sections.]

WOOLWICH STANDARD.

FULL SIZE.

	Tons per square inch at—		Elongation in a specimen which has the breaking part 2 inches long.
	Yielding.	Breaking.	
			Inch.
Soft:			
Low	11.5 up to 14.0	28.5 up to 34.0	.20 up to .60
High			or anything above.
Tempered:			
Low	29.0 up to 34.0	40.0 up to 58.0	.05 up to .30
High			or anything above.

Diameter of testing piece .533" = area .2231" .2231" × 4½ = say 1 square inch.



Report of tests by tensile strain on specimens cut from 5 8-*inch jackets, supplied to Messrs. Paulding, Kemble & Co., West Point Foundry, March* 30, 1881, *from Messrs. Firth & Sons.*

TESTS FROM JACKETS BEFORE OIL TEMPERING.

Breaking strain per square inch:

S. Soft	tons	32.17
L. Tempered	do	46.34⅜
H. Tempered	do	46.91

Elongation:

S. Soft	inches	.55⅛
L. Tempered	do	.39⅛
H. Tempered	do	.38

TESTS FROM JACKETS AFTER OIL TEMPERING.

Breaking strain per square inch:

O. H. •	tons	38.76⅜
O. H. • •	do	43.62⅝
O. H. •·•	do	40.72⅛

Elongation:

O. H. •	inches..	.22⅘
O. H. ••	do....	.25
O. H. ∴	do....	.20⅘

Results of tests by tensile strain on specimens cut from 5 8-*inch slide bars supplied to Messrs. Paulding, Kemble & Co., West Point Foundry, March* 30, 1881.

TESTS FROM SLIDE BARS BEFORE OIL TEMPERING.

Breaking strain per square inch:

S. soft	tons..	34.68
L. tempered	do...	54.33⅕
H. tempered	do...	51.97

Elongation:

S. soft	inches..	.35⅗
L. tempered	do....	.19
H. tempered	do....	.19⅗

TESTS FROM SLIDE BARS AFTER OIL TEMPERING.

Breaking strain per square inch:

S. soft	tons..	39.77⅗
L. tempered	do...	40.79
H. tempered	do...	40.04⅖

Elongation:

S. soft	inches..	.23⅗
L. tempered	do....	.17⅗
H. tempered	do....	.25

Results of tests by tensile strain on specimens cut from 11-*inch jacket and* 11-*inch slide bar supplied to Messrs. Paulding, Kemble & Co., April* 7, 1881.

TESTS FROM JACKET.

Breaking strain per square inch:

S. soft	tons..	27.90
L. tempered	do...	42.07
H. tempered	do...	40.72

Elongation:

S. soft	inches..	.55
L. tempered	do....	.40
H. tempered	do....	.42

TESTS FROM SLIDE BAR.

Breaking strain per square inch:

S. soft	tons..	32.96
L. tempered	do...	51.86
H. tempered	do...	54.22

Elongation:

S. soft	inches..	.54
L. tempered	do....	.16
H. tempered	do....	.22

SPECIMEN MARKED No. 2.

Table showing the extension, restoration, and permanent set caused by the undermentioned weights per square inch of section acting upon a solid cylinder 3 inches long and 0.563 inch in diameter of Firth's steel (oil-tempered), taken longitudinally from interior of breech receiver of 8-inch breech-loading rifle No. 5 (chambered), after rupture.

Weight per square inch of section.	Extension per inch in length.	Successive extension per inch in length.	Restoration per inch in length.	Successive restoration per inch in length.	Permanent set per inch in length.	Successive permanent set per inch in length.
Pounds.	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
1,000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2,000	.0000	.0000	.0000	.0000	.0000	.0000
3,000	.0000	.0000	.0000	.0000	.0000	.0000
4,000	.0000	.0000	.0000	.0000	.0000	.0000
5,000	.0000	.0000	.0000	.0000	.0000	.0000
6,000	.0002	.0002	.0002	.0002	.0000	.0000
7,000	.0003	.0001	.0003	.0001	.0000	.0000
8,000	.0003	.0000	.0003	.0000	.0000	.0000
9,000	.0003	.0000	.0003	.0000	.0000	.0000
10,000	.0003	.0000	.0003	.0000	.0000	.0000
11,000	.0003	.0000	.0003	.0000	.0000	.0000
12,000	.0003	.0000	.0003	.0000	.0000	.0000
13,000	.0003	.0000	.0003	.0000	.0000	.0000
14,000	.0003	.0000	.0003	.0000	.0000	.0000
15,000	.0005	.0002	.0005	.0002	.0000	.0000
16,000	.0005	.0000	.0005	.0000	.0000	.0000
17,000	.0005	.0000	.0005	.0000	.0000	.0000
18,000	.0005	.0000	.0005	.0000	.0000	.0000
19,000	.0006	.0001	.0006	.0001	.0000	.0000
20,000	.0006	.0000	.0006	.0000	.0000	.0000
21,000	.0006	.0000	.0006	.0000	.0000	.0000
22,000	.0006	.0000	.0006	.0000	.0000	.0000
23,000	.0006	.0000	.0006	.0000	.0000	.0000
24,000	.0008	.0002	.0008	.0002	.0000	.0000
25,000	.0008	.0000	.0008	.0000	.0000	.0000
26,000	.0010	.0002	.0010	.0002	.0000	.0000
27,000	.0010	.0000	.0010	.0000	.0000	.0000
28,000	.0010	.0000	.0010	.0000	.0000	.0000
29,000	.0010	.0000	.0010	.0000	.0000	.0000
30,000	.0010	.0000	.0010	.0000	.0000	.0000
31,000	.0013	.0003	.0013	.0003	.0000	.0000
32,000	.0013	.0000	.0013	.0000	.0000	.0000
33,000	.0013	.0000	.0013	.0000	.0000	.0000
34,000	.0013	.0000	.0013	.0000	.0000	.0000
35,000	.0013	.0000	.0013	.0000	.0000	.0000
36,000	.0013	.0000	.0013	.0000	.0000	.0000
37,000	.0015	.0002	.0015	.0002	.0000	.0000
38,000	.0015	.0000	.0015	.0000	.0000	.0000
39,000	.0015	.0000	.0015	.0000	.0000	.0000
40,000	.0016	.0001	.0016	.0001	.0000	.0000
41,000	.0016	.0000	.0016	.0000	.0000	.0000
42,000	.0016	.0000	.0016	.0000	.0000	.0000
43,000	.0016	.0000	.0016	.0000	.0000	.0000
44,000	.0016	.0000	.0016	.0000	.0000	.0000
45,000	.0016	.0000	.0016	.0000	.0000	.0000
46,000	.0018	.0002	.0018	.0002	.0000	.0000
47,000	.0018	.0000	.0018	.0000	.0000	.0000
48,000	.0018	.0000	.0018	.0000	.0000	.0000
49,000	.0020	.0002	.0020	.0002	.0000	.0000
50,000	.0020	.0000	.0020	.0000	.0000	.0000
51,000	.0021	.0001	.0021	.0001	.0000	.0000
52,000	.0021	.0000	.0021	.0000	.0000	.0000
53,000	.0021	.0000	.0021	.0000	.0000	.0000
54,000	.0021	.0000	.0021	.0000	.0000	.0000
55,000	.0021	.0000	.0021	.0000	.0000	.0000
56,000	.0021	.0000	.0021	.0000	.0000	.0000
57,000	.0023	.0002	.0023	.0002	.0000	.0000
58,000	.0023	.0000	.0023	.0000	.0000	.0000
59,000	.0023	.0000	.0023	.0000	.0000	.0000
60,000	.0023	.0000	.0023	.0000	.0000	.0000
61,000	.0025	.0002	.0022	—.0001	.0003	.0003
62,000	.0025	.0000	.0022	.0000	.0003	.0000
63,000	.0025	.0000	.0022	.0000	.0003	.0000
64,000	.0025	.0000	.0022	.0000	.0003	.0000
65,000	.0026	.0001	.0023	.0001	.0003	.0000
66,000	.0030	.0004	.0027	.0004	.0003	.0000
67,000	.0036	.0006	.0033	.0006	.0003	.0000
68,000	.0040	.0004	.0030	—.0003	.0010	.0007
69,000	.0050	.0010	.0034	.0004	.0016	.0006
70,000	.0063	.0013	.0033	—.0001	.0030	.0014

Table showing the extension, restoration, &c.—Continued.

Weight per square inch of section.	Extension per inch in length.	Successive extension per inch in length.	Restoration per inch in length.	Successive restoration per inch in length.	Permanent set per inch in length.	Successive permanent set per inch in length.
Pounds.	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
71, 000	.0070	.0007	.0034	.0001	.0036	.0006
72, 000	.0080	.0010	.0037	.0003	.0043	.0007
73, 000	.0086	.0006	.0036	—.0001	.0050	.0007
74, 000	.0090	.0004	.0037	.0001	.0053	.0003
75, 000	.0096	.0006	.0036	—.0001	.0060	.0007
76, 000	.0103	.0007	.0040	.0004	.0063	.0003
77, 000	.0110	.0007	.0040	.0000	.0070	.0007
78, 000	.0116	.0006	.0043	.0003	.0073	.0003
79, 000	.0120	.0004	.0044	.0001	.0076	.0003
80, 000	.0123	.0003	.0040	—.0004	.0083	.0007
81, 000	.0130	.0007	.0040	.0000	.0090	.0007
82, 000	.0143	.0013	.0047	.0007	.0096	.0006
83, 000	.0146	.0003	.0046	—.0001	.0100	.0004
84, 000	.0153	.0007	.0047	.0001	.0106	.0006
85, 000	.0163	.0010	.0047	.0000	.0116	.0010
86, 000	.0166	.0003	.0046	—.0001	.0120	.0004
87, 000	.0173	.0007	.0043	—.0003	.0130	.0010
88, 000	.0183	.0010	.0047	.0004	.0136	.0006
89, 000	.0186	.0003	.0043	—.0004	.0143	.0007
90, 000	.0200	.0014	.0054	.0011	.0146	.0003
91, 000	.0213	.0013	.0057	.0003	.0156	.0010
92, 000	.0220	.0007	.0054	—.0003	.0166	.0010
93, 000	.0230	.0010	.0057	.0003	.0173	.0007
94, 000	.0236	.0006	.0053	—.0004	.0183	.0010
95, 000	.0246	.0010	.0056	.0003	.0190	.0007
96, 000	.0263	.0017	.0057	.0001	.0206	.0016
97, 000	.0273	.0010	.0057	.0000	.0216	.0010
98, 000	.0290	.0017	.0060	.0003	.0230	.0014
99, 000	.0303	.0013	.0063	.0003	.0240	.0010
100, 000	.0313	.0010	.0060	—.0003	.0253	.0013
101, 000	.0323	.0010	.0060	.0000	.0263	.0010
102, 000	.0346	.0023	.0066	.0006	.0280	.0017
103, 000	.0356	.0010	.0060	—.0006	.0296	.0016
104, 000	.0370	.0014	.0060	.0000	.0310	.0014
105, 000	.0400	.0030	.0067	.0007	.0333	.0023
106, 000	.0413	.0013	.0067	.0000	.0346	.0013
107, 000	.0430	.0017	.0064	—.0003	.0366	.0020
108, 000	.0450	.0020	.0060	—.0004	.0390	.0024
109, 000	.0480	.0030	.0060	.0000	.0420	.0030
110, 000	.0513	.0033	.0070	.0010	.0443	.0023
111, 000	.0540	.0027	.0067	—.0003	.0473	.0030
112, 000	.0596	.0056	.0016	—.0051	.0580	.0107

GENERAL SUMMARY.

Specific gravity		
Tenacity	pounds	
Elastic limit	do	61, 000
Extension per inch at elastic limit	inch	.0025
Ultimate resistance	pounds	112, 000
Ultimate extension	inch	0.0596
Hardness		22
Reduction in diameter at rupture	inch	0.018
Original area of cross-section	square inch	0.24894
Area after rupture	do	0.23338
Reduction in area at rupture		6¼ per cent.
Position of rupture		near middle.
Character of surface		fine granular.

SPECIMEN MARKED NO. 4.

Table showing the extension, restoration, and permanent set caused by the undermentioned weights per square inch of section acting upon a solid cylinder 3 inches long and 0.563 *inch in diameter of Firth's steel (oil-tempered), taken longitudinally from interior of breech receiver of* 8-*inch breech-loading rifle No.* 5 *(chambered), after rupture.*

Weight per square inch of section.	Extension per inch in length.	Successive extension per inch in length.	Restoration per inch in length.	Successive restoration per inch in length.	Permanent set per inch in length.	Successive permanent set per inch in length.
Pounds.	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
1,000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2,000	.0000	.0000	.0000	.0000	.0000	.0000
3,000	.0000	.0000	.0000	.0000	.0000	.0000
4,000	.0000	.0000	.0000	.0000	.0000	.0000
5,000	.0000	.0000	.0000	.0000	.0000	.0000
6,000	.0000	.0000	.0000	.0000	.0000	.0000
7,000	.0003	.0003	.0003	.0003	.0000	.0000
8,000	.0003	.0000	.0003	.0000	.0000	.0000
9,000	.0003	.0000	.0003	.0000	.0000	.0000
10,000	.0003	.0000	.0003	.0000	.0000	.0000
11,000	.0003	.0000	.0003	.0000	.0000	.0000
12,000	.0003	.0000	.0003	.0000	.0000	.0000
13,000	.0003	.0000	.0003	.0000	.0000	.0000
14,000	.0003	.0000	.0003	.0000	.0000	.0000
15,000	.0005	.0002	.0005	.0002	.0000	.0000
16,000	.0005	.0000	.0005	.0000	.0000	.0000
17,000	.0005	.0000	.0005	.0000	.0000	.0000
18,000	.0006	.0001	.0006	.0001	.0000	.0000
19,000	.0006	.0000	.0006	.0000	.0000	.0000
20,000	.0006	.0000	.0006	.0000	.0000	.0000
21,000	.0006	.0000	.0006	.0000	.0000	.0000
22,000	.0008	.0002	.0008	.0002	.0000	.0000
23,000	.0008	.0000	.0008	.0000	.0000	.0000
24,000	.0008	.0000	.0008	.0000	.0000	.0000
25,000	.0008	.0000	.0008	.0000	.0000	.0000
26,000	.0010	.0002	.0010	.0002	.0000	.0000
27,000	.0010	.0000	.0010	.0000	.0000	.0000
28,000	.0010	.0000	.0010	.0000	.0000	.0000
29,000	.0010	.0000	.0010	.0000	.0000	.0000
30,000	.0012	.0002	.0012	.0002	.0000	.0000
31,000	.0012	.0000	.0012	.0000	.0000	.0000
32,000	.0012	.0000	.0012	.0000	.0000	.0000
33,000	.0012	.0000	.0012	.0000	.0000	.0000
34,000	.0012	.0000	.0012	.0000	.0000	.0000
35,000	.0013	.0001	.0013	.0001	.0000	.0000
36,000	.0013	.0000	.0013	.0000	.0000	.0000
37,000	.0013	.0000	.0013	.0000	.0000	.0000
38,000	.0013	.0000	.0013	.0000	.0000	.0000
39,000	.0013	.0000	.0013	.0000	.0000	.0000
40,000	.0013	.0000	.0013	.0000	.0000	.0000
41,000	.0013	.0000	.0013	.0000	.0000	.0000
42,000	.0013	.0000	.0013	.0000	.0000	.0000
43,000	.0013	.0000	.0013	.0000	.0000	.0000
44,000	.0013	.0000	.0013	.0000	.0000	.0000
45,000	.0013	.0000	.0013	.0000	.0000	.0000
46,000	.0015	.0002	.0015	.0002	.0000	.0000
47,000	.0015	.0000	.0015	.0000	.0000	.0000
48,000	.0015	.0000	.0015	.0000	.0000	.0000
49,000	.0015	.0000	.0015	.0000	.0000	.0000
50,000	.0020	.0005	.0017	.0002	.0003	.0003
51,000	.0053	.0033	.0023	.0006	.0030	.0027
52,000	.0066	.0013	.0030	.0007	.0036	.0006
53,000	.0083	0017	.0043	.0013	.0040	.0004
54,000	.0090	.0007	.0030	—.0013	.0060	.0020
55,000	.0093	.0003	.0027	—.0003	.0066	.0006
56,000	.0103	.0010	.0030	.0003	.0073	.0007
57,000	.0110	.0007	.0034	.0004	.0076	.0003
58,000	.0113	.0003	.0030	—.0004	.0083	.0007
59,000	.0123	.0010	.0033	.0003	.0090	.0007
60,000	.0126	.0003	.0033	.0000	.0093	.0003
61,000	.0133	.0007	.0033	.0000	.0100	.0007
62,000	.0140	.0007	.0034	.0001	.0106	.0006
63,000	.0150	.0010	.0034	.0000	.0116	.0010
64,000	.0156	.0006	.0030	—.0004	.0126	.0010
65,000	.0170	.0014	.0037	.0007	.0133	.0007
66,000	.0180	.0010	.0037	.0000	.0143	.0010
67,000	.0186	.0006	.0036	—.0001	.0150	.0007
68,000	.0196	.0010	.0040	.0004	0156	.0006
69,000	.0206	.0010	.0040	.0000	.0166	.0010
70,000	.0216	.0010	.0040	.0000	.0176	.0010
71,000	.0233	.0017	.0040	.0000	.0193	.0017

Table showing the extension, restoration, &c.—Continued.

Weight per square inch of section.	Extension per inch in length.	Successive extension per inch in length.	Restoration per inch in length.	Successive restoration per inch in length.	Permanent set per inch in length.	Successive permanent set per inch in length.
Pounds.	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
72, 000	. 0243	. 0010	. 0040	. 0000	. 0203	. 0010
73, 000	. 0260	. 0017	. 0044	. 0004	. 0216	. 0013
74, 000	. 0273	. 0013	. 0047	. 0003	. 0226	. 0010
75, 000	. 0286	. 0013	. 0043	—. 0004	. 0243	. 0017
76, 000	. 0300	. 0014	. 0044	. 0001	. 0256	. 0013
77, 000	. 0323	. 0023	. 0047	. 0003	. 0276	. 0020
78, 000	. 0343	. 0020	. 0047	. 0000	. 0296	. 0020
79, 000	. 0363	. 0020	. 0047	. 0000	. 0316	. 0020
80, 000	. 0376	. 0013	. 0046	—. 0001	. 0330	. 0014
81, 000	. 0393	. 0017	. 0050	. 0004	. 0343	. 0013
82, 000	. 0416	. 0023	. 0053	. 0003	. 0363	. 0020
83, 000	. 0443	. 0027	. 0053	. 0000	. 0390	. 0027
84, 000	. 0476	. 0033	. 0053	. 0000	. 0423	. 0033
85, 000	. 0500	. 0024	. 0047	—. 0006	. 0453	. 0030
86, 000	. 0533	. 0033	. 0060	. 0013	. 0473	. 0020
87, 000	. 0566	. 0033	. 0056	—. 0004	. 0510	. 0027
88, 000	. 0616	. 0050	. 0056	. 0000	. 0560	. 0050
89, 000	. 0666	. 0050	. 0060	. 0004	. 0606	. 0046
90, 000	. 0700	. 0034	. 0044	—. 0016	. 0656	. 0050
91, 000	. 0783	. 0083	. 0063	. 0019	. 0720	. 0064
92, 000	. 0833	. 0050	. 0050	—. 0013	. 0783	. 0063

GENERAL SUMMARY.

Specific gravity		
Tenacity	pounds	
Elastic limit	do	50, 000
Extension per inch at elastic limit	inch	0. 0020
Ultimate resistance	pounds	92, 000
Ultimate extension	inch	0. 0833
Hardness		20. 6
Reduction in diameter at rupture	inch	0. 032
Original area of cross-section	square inch	0. 24894
Area after rupture	do	0. 22145
Reduction in area at rupture		11 per cent.
Position of rupture		⅛ inch from lower shoulder.
Character of surface		fine granular.

SPECIMEN OF FIRTH'S STEEL (OIL-TEMPERED), MARKED NO. 6.

Table showing the extension, restoration, and permanent set caused by the undermentioned weights per square inch of area acting upon a solid cylinder 3 *inches long and* 0.562 *inch in diameter, taken longitudinally from outside of breech receiver from* 8-*inch breech-loading rifle No.* 5, *after rupture.*

Weight per square inch of original area.	Extension per inch in length.	Successive extension per inch in length.	Restoration per inch in length.	Successive restoration per inch in length.	Permanent set per inch in length.	Successive permanent set per inch in length.
Pounds.	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
1, 000	0. 0000	0. 0000	0. 0000	0. 0000	0. 0000	0. 0000
2, 000	. 0000	. 0000	. 0000	. 0000	. 0000	. 0000
3, 000	. 0000	. 0000	. 0000	. 0000	. 0000	. 0000
4, 000	. 0000	. 0000	. 0000	. 0000	. 0000	. 0000
5, 000	. 0010	. 0010	. 0010	. 0000	. 0000	. 0000
6, 000	. 0010	. 0000	. 0010	. 0000	. 0000	. 0000
7, 000	. 0010	. 0000	. 0010	. 0000	. 0000	. 0000
8, 000	. 0010	. 0000	. 0010	. 0000	. 0000	. 0000
9, 000	. 0010	. 0000	. 0010	. 0000	. 0000	. 0000
10, 000	. 0010	. 0000	. 0010	. 0000	. 0000	. 0000
11, 000	. 0010	. 0000	. 0010	. 0000	. 0000	. 0000
12, 000	. 0010	. 0000	. 0010	. 0000	. 0000	. 0000
13, 000	. 0010	. 0000	. 0010	. 0000	. 0000	. 0000
14, 000	. 0010	. 0000	. 0010	. 0000	. 0000	. 0000
15, 000	. 0010	. 0000	. 0010	. 0000	. 0000	. 0000
16, 000	. 0010	. 0000	. 0010	. 0000	. 0000	. 0000
17, 000	. 0010	. 0000	. 0010	. 0000	. 0000	. 0000

Table showing the extension, restoration, &c.—Continued.

Weight per square inch of original area.	Extension per inch in length.	Successive extension per inch in length.	Restoration per inch in length.	Successive restoration per inch in length.	Permanent set per inch in length.	Successive permanent set per inch in length.
Pounds.	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
18,000	.0010	.0000	.0010	.0000	.0000	.0000
19,000	.0010	.0600	.0010	.0000	.0000	.0000
20,000	.0010	.0000	.0010	.0000	.0000	.0000
21,000	.0010	.0000	.0010	.0000	.0000	.0000
22,000	.0910	.0000	.0010	.0000	.0000	.0000
23,000	.0010	.0000	.0010	.0000	.0000	.0000
24,000	.0010	.0000	.0010	.0000	.0000	.0000
25,000	.0010	.0000	.0010	.0000	.0000	.0000
26,000	.0010	.0000	.0010	.0000	.0000	.0000
27,000	.0010	.0000	.0010	.0000	.0000	.0000
28,000	.0012	.0002	.0012	.0002	.0000	.0000
29,000	.0012	.0000	.0012	.0000	.0000	.0000
30,000	.0015	.0003	.0015	.0000	.0000	.0000
31,000	.0016	.0001	.0016	.0003	.0000	.0000
32,000	.0016	.0000	.0016	.0001	.0000	.0000
33,000	.0016	.0000	.0016	.0000	.0000	.0000
34,000	.0016	.0000	.0016	.0000	.0000	.0000
35,000	.0016	.0000	.0016	.0000	.0000	.0000
36,000	.0016	.0000	.0016	.0000	.0000	.0000
37,000	.0016	.0000	.0016	.0000	.0000	.0000
38,000	.0016	.0000	.0016	.0000	.0000	.0000
39,000	.0016	.0000	.0016	.0000	.0000	.0000
40,000	.0016	.0000	.0016	.0000	.0000	.0000
41,000	.0016	.0000	.0016	.0000	.0000	.0000
42,000	.0016	.0000	.0016	.0000	.0000	.0000
43,000	.0020	.0004	.0020	.0004	.0000	.0000
44,000	.0020	.0000	.0020	.0000	.0000	.0000
45,000	.0023	.0003	.0020	.0000	.0003	.0003
46,000	.0030	.0007	.0020	.0000	.0010	.0007
47,000	.0033	.0003	.0020	.0000	.0013	.0003
48,000	.0036	.0003	.0020	.0000	.0016	.0003
49,000	.0036	.0000	.0020	.0000	.0016	.0000
50,000	.0040	.0004	.0024	.0004	.0016	.0000
51,000	.0046	.0006	.0023	—.0001	.0023	.0007
52,000	.0050	.0004	.0024	.0001	.0026	.0003
53,000	.0056	.0006	.0026	—.0002	.0030	.0004
54,000	.0070	.0014	.0024	—.0002	.0046	.0016
55,000	.0100	.0030	.0030	.0006	.0070	.0024
56,000	.0106	.0006	.0026	—.0004	.0080	.0010
57,000	.0116	.0010	.0033	.0007	.0083	.0003
58,000	.0126	.0010	.0033	.0000	.0093	.0010
59,000	.0133	.0007	.0033	.0000	.0100	.0007
60,000	.0136	.0003	.0033	.0000	.0103	.0003
61,000	.0146	.0010	.0036	.0003	.0110	.0007
62,000	.0153	.0007	.0030	—.0006	.0123	.0013
63,000	.0163	.0010	.0033	.0003	.0130	.0007
64,000	.0173	.0010	.0033	.0000	.0140	.0010
65,000	.0180	.0007	.0034	.0001	.0146	.0006
66,000	.0190	.0010	.0037	.0003	.0153	.0007
67,000	.0203	.0013	.0037	.0000	.0166	.0013
68,000	.0216	.0013	.0043	.0006	.0173	.0007
69,000	.0220	.0004	.0040	—.0003	.0180	.0007
70,000	.0236	.0016	.0043	.0003	.0193	.0013
71,000	.0250	.0014	.0040	—.0003	.0210	.0017
72,000	.0260	.0010	.0040	.0000	.0220	.0010
73,000	.0276	.0016	.0043	—.0003	.0233	.0013
74,000	.0290	.0014	.0047	.0004	.0243	.0010
75,000	.0303	.0013	.0043	—.0004	.0260	.0017
76,000	.0320	.0017	.0044	.0001	.0276	.0016
77,000	.0340	.0020	.0047	.0003	.0293	.0017
78,000	.0353	.0013	.0043	—.0004	.0310	.0017
79,000	.0406	.0053	.0033	—.0010	.0373	.0063

GENERAL SUMMARY.

Specific gravity		
Hardness		19.49
Tenacity	pounds	
Elastic limit	do	45,000
Extension per inch at elastic limit	inch	0.0023
Ultimate resistance per square inch of original area	pounds	79,000
Ultimate extension per inch	inch	0.0406
Ratio of elastic to ultimate resistance		1 to 1.75
Contraction in area at fracture		3 per cent.
Ultimate resistance per square inch of fractured area	pounds	81,294
Position of fracture		near middle.
Character of surface		fine grain.

SPECIMEN OF FIRTH'S STEEL (OIL-TEMPERED), MARKED NO. 7.

Table showing the extension, restoration, and permanent set caused by the undermentioned weights per square inch of area acting upon a solid cylinder 3 inches long and 0.563 inch in diameter, taken longitudinally from outside of breech receiver from 8-inch breech-loading rifle No. 5, after rupture.

Weight per square inch of original area.	Extension per inch in length.	Successive extension per inch in length.	Restoration per inch in length.	Successive restoration per inch in length.	Permanent set per inch in length.	Successive permanent set per inch in length.
Pounds.	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
1, 000	0. 0000	0. 0000	0. 0000	0. 0000	0. 0000	0. 0000
2, 000	. 0000	. 0000	. 0000	. 0000	. 0000	. 0000
3, 000	. 0000	. 0000	. 0000	. 0000	. 0000	. 0000
4, 000	. 0000	. 0000	. 0000	. 0000	. 0000	. 0000
5, 000	. 0003	. 0003	. 0003	. 0003	. 0000	. 0000
6, 000	. 0005	. 0002	. 0005	. 0002	. 0000	. 0000
7, 000	. 0005	. 0000	. 0005	. 0000	. 0000	. 0000
8, 000	. 0006	. 0001	. 0006	. 0001	. 0000	. 0000
9, 000	. 0006	. 0000	. 0006	. 0000	. 0000	. 0000
10, 000	. 0006	. 0000	. 0006	. 0000	. 0000	. 0000
11, 000	. 0008	. 0002	. 0008	. 0002	. 0000	. 0000
12, 000	. 0008	. 0000	. 0008	. 0000	. 0000	. 0000
13, 000	. 0008	. 0000	. 0008	. 0000	. 0000	. 0000
14, 000	. 0010	. 0002	. 0010	. 0002	. 0000	. 0000
15, 000	. 0010	. 0000	. 0010	. 0000	. 0000	. 0000
16, 000	. 0016	. 0000	. 0010	. 0000	. 0000	. 0000
17, 000	. 0010	. 0000	. 0010	. 0000	. 0000	. 0000
18, 000	. 0010	. 0000	. 0010	. 0000	. 0000	. 0000
19, 000	. 0011	. 0001	. 0011	. 0001	. 0000	. 0000
20, 000	. 0011	. 0000	. 0011	. 0000	. 0000	. 0000
21, 000	. 0011	. 0000	. 0011	. 0000	. 0000	. 0000
22, 000	. 0013	. 0002	. 0013	. 0002	. 0000	. 0000
23, 000	. 0013	. 0000	. 0013	. 0000	. 0000	. 0000
24, 000	. 0014	. 0000	. 0013	. 0000	. 0000	. 0000
25, 000	. 0013	. 0000	. 0013	. 0000	. 0000	. 0000
26, 000	. 0013	. 0000	. 0013	. 0000	. 0000	. 0000
27, 000	. 0013	. 0000	. 0013	. 0000	. 0000	. 0000
28, 000	. 0013	. 0000	. 0013	. 0000	. 0000	. 0000
29, 000	. 0013	. 0000	. 0013	. 0000	. 0000	. 0000
30, 000	. 0013	. 0000	. 0013	. 0000	. 0000	. 0000
31, 000	. 0013	. 0000	. 0013	. 0000	. 0000	. 0000
32, 000	. 0013	. 0000	. 0013	. 0000	. 0000	. 0000
33, 000	. 0013	. 0000	. 0013	. 0000	. 0000	. 0000
34, 000	. 0013	. 0000	. 0013	. 0000	. 0000	. 0000
35, 000	. 0013	. 0000	. 0013	. 0000	. 0000	. 0000
36, 000	. 0013	. 0000	. 0013	. 0000	. 0000	. 0000
37, 000	. 0013	. 0000	. 0013	. 0000	. 0000	. 0000
38, 000	. 0013	. 0000	. 0013	. 0000	. 0000	. 0000
39, 000	. 0015	. 0002	. 0015	. 0002	. 0000	. 0000
40, 000	. 0015	. 0000	. 0015	. 0000	. 0000	. 0000
41, 000	. 0015	. 0000	. 0015	. 0000	. 0000	. 0000
42, 000	. 0015	. 0000	. 0015	. 0000	. 0000	. 0000
43, 000	. 0015	. 0000	. 0015	. 0000	. 0000	. 0000
44, 000	. 0015	. 0000	. 0015	. 0000	. 0000	. 0000
45, 000	. 0016	. 0001	. 0016	. 0001	. 0000	. 0000
46, 000	. 0016	. 0000	. 0016	. 0000	. 0000	. 0000
47, 000	. 0016	. 0000	. 0016	. 0000	. 0000	. 0000
48, 000	. 0018	. 0002	. 0018	. 0002	. 0000	. 0000
49, 000	. 0020	. 0002	. 0020	. 0002	. 0000	. 0000
50, 000	. 0020	. 0000	. 0020	. 0000	. 0000	. 0000
51, 000	. 0023	. 0003	. 0023	. 0003	. 0000	. 0000
52, 000	. 0036	. 0013	. 0026	. 0003	. 0010	. 0010
53, 000	. 0043	. 0007	. 0020	—. 0006	. 0023	. 0013
54, 000	. 0060	. 0017	. 0027	. 0007	. 0033	. 0010
55, 000	. 0066	. 0006	. 0026	—. 0001	. 0040	. 0007
56, 000	. 0076	. 0010	. 0026	. 0000	. 0050	. 0010
57, 000	. 0083	. 0007	. 0027	. 0001	. 0056	. 0006
58, 000	. 0090	. 0007	. 0030	. 0003	. 0060	. 0004
59, 000	. 0096	. 0006	. 0030	. 0000	. 0066	. 0006
60, 000	. 0103	. 0007	. 0030	. 0000	. 0073	. 0007
61, 000	. 0113	. 0010	. 0030	. 0000	. 0083	. 0010
62, 000	. 0123	. 0010	. 0033	. 0003	. 0090	. 0007
63, 000	. 0130	. 0007	. 0034	. 0001	. 0096	. 0006
64, 000	. 0136	. 0006	. 0033	—. 0001	. 0103	. 0007
65, 000	. 0146	. 0010	. 0033	. 0000	. 0113	. 0010
66, 000	. 0156	. 0010	. 0033	. 0000	. 0123	. 0010
67, 000	. 0166	. 0010	. 0036	. 0003	. 0130	. 0007
68, 000	. 0173	. 0007	. 0037	. 0001	. 0136	. 0006
69 000	. 0183	. 0010	. 0037	. 0000	. 0146	. 0010
70, 000	. 0190	. 0007	. 0037	. 0000	. 0153	. 0007
71, 000	. 0203	. 0013	. 0040	. 0003	. 0163	. 0010

Table showing the extension, restoration, and permanent set, &c.—Continued.

Weight per square inch of original area.	Extension per inch in length.	Successive extension per inch in length.	Restoration per inch in length.	Successive restoration per inch in length.	Permanent set per inch in length.	Successive permanent set per inch in length.
Pounds.	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
72, 000	.0210	.0007	.0040	.0000	.0170	.0007
73, 000	.0223	.0013	.0040	.0000	.0183	.0013
74, 000	.0233	.0010	.0040	.0000	.0193	.0010
75, 000	.0246	.0013	.0043	.0003	.0203	.0010
76, 000	.0260	.0014	.0044	.0001	.0216	.0013
77, 000	.0280	.0020	.0047	.0003	.0233	.0017
78, 000	.0290	.0010	.0044	—.0003	.0246	.0013
79, 000	.0306	.0016	.0050	.0006	.0256	.0010
80, 000	.0323	.0017	.0043	—.0007	.0280	.0024
81, 000	.0346	.0023	.0053	.0010	.0293	.0013
82, 000	.0370	.0024	.0054	.0001	.0316	.0023
83, 000	.0390	.0020	.0054	.0000	.0336	.0020
84, 000	.0410	.0020	.0054	.0000	.0356	.0020
85, 000	.0423	.0013	.0053	—.0001	.0370	.0014
86, 000	.0446	.0023	.0053	.0000	.0393	.0023
87, 000	.0476	.0030	.0053	.0000	.0423	.0030
88, 000	.0506	.0030	.0050	—.0003	.0456	.0033
89, 000	.0546	.0040	.0056	.0006	.0490	.0034
90, 000	.0570	.0024	.0054	—.0002	.0516	.0026
91, 000	.0606	.0036	.0056	.0002	.0550	.0034
92, 000	.0660	.0054	.0060	.0004	.0600	.0050
93, 000	.0713	.0053	.0060	.0000	.0653	.0053
94, 000	.0780	.0067	.0067	.0007	.0713	.0060
95, 000	.0880	.0100	.0064	—.0003	.0816	.0103

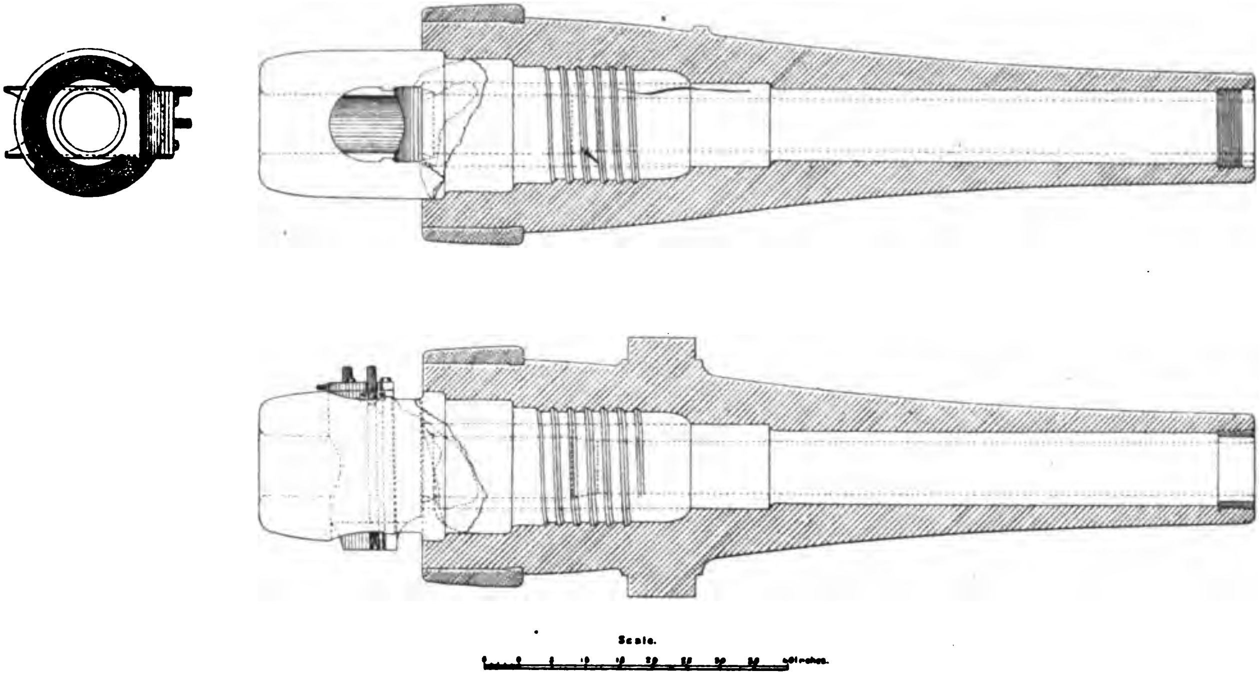
GENERAL SUMMARY.

Specific gravity		
Hardness		20.50
Tenacity	pounds	
Elastic limit	do	52, 000
Extension per inch at elastic limit	inch	0.0036
Ultimate resistance per square inch of original area	pounds	95, 000
Ultimate extension per inch	inch	0.0880
Ratio of elastic to ultimate resistance		1 to 1.82
Contraction in area at fracture		6 per cent.
Ultimate resistance per square inch of fractured area	pounds	101, 089
Position of fracture		near lower shoulder.
Character of surface		granular and crystalline.

PLATE I.

8 INCH B. L. CHAMBERED RIFLE, SHOWING LINES OF FRACTURE ON JACKET.

(GUN No 5)



Appendix 16—1882.

APPENDIX 17.

REPORT OF THE BOARD ON HEAVY ORDNANCE AND PROJECTILES, UNDER ACT APPROVED MARCH 3, 1881.

(10 plates.)

[Senate Ex. Doc. No. 178, Forty-seventh Congress, first session.]

Letter from the Secretary of War, transmitting the report of the Board appointed under the act of Congress of March 3, 1881, *to make examinations of inventions of heavy ordnance and improvements of heavy ordnance and projectiles, and to recommend what inventions are worthy of actual test, &c.*

MAY 29, 1882.—Ordered to lie on the table.
MAY 31, 1882.—Referred to the Committee on Appropriations and ordered to be printed.

WAR DEPARTMENT,
Washington City, May 29, 1882.

The Secretary of War has the honor to transmit to the Senate the report of the Board selected by the President, under the authority of the act of Congress approved March 3, 1881, "to make examinations of all inventions of heavy ordnance and improvements of heavy ordnance and projectiles that may be presented to them, including guns now being constructed or converted under the direction of the Ordnance Bureau," and to recommend "what inventions are worthy of actual test, and the estimated cost of such test."

In the communication of the president of the Board transmitting the report of the Board to the War Department, it is stated that certain "accompanying documents referred to in a note to the report, which are very numerous, will be forwarded in a short time, as soon as they can be prepared." They have not yet been received at this department. The documents referred to will be comprised in appendices numbered III, IV, V, and VI, and their character is briefly indicated in a note attached to the report of the Board.

These documents will be transmitted to the Senate as soon as they shall be received at the War Department.

ROBERT T. LINCOLN,
Secretary of War.

The PRESIDENT *pro tempore, United States Senate.*

Report of the Board on Heavy Ordnance and Projectiles appointed in pursuance of the act of Congress approved March 3, 1881, for the purpose of "making examinations of all inventions of heavy ordnance and improvements of heavy ordnance and projectiles that may be presented to them, including guns now being constructed or converted under direction of the Ordnance Bureau."

OFFICE OF THE BOARD ON HEAVY ORDNANCE
AND PROJECTILES, ARMY BUILDING,
GREENE AND HOUSTON STREETS,
New York City, May 18, 1882.

The Board met at this place on the 13th day of July, 1881, in compliance with the following order:

GENERAL ORDERS No. 48.
HEADQUARTERS OF THE ARMY,
ADJUTANT-GENERAL'S OFFICE,
Washington, May 16, 1881.

The following order from the War Department is published for the information of all concerned:

"The act making appropriations for fortifications and other works of defense, and for the armament thereof, for the fiscal year ending June 30, 1882, and for other purposes," approved March 3, 1881, provides:

"And the President is authorized to select a Board, to consist of one Engineer officer, two Ordnance officers, and two officers of Artillery, whose duty it shall be to make examinations of all inventions of heavy ordnance and improvements of heavy ordnance and projectiles that may be presented to them, including guns now being constructed or converted under direction of the Ordnance Bureau; and said Board shall make detailed report to the Secretary of War, for transmission to Congress, of such examination, with recommendation as to what inventions are worthy of actual test, and the estimated cost of such test; and the sum of $25,000, or so much thereof as may be necessary, is hereby appropriated for such purpose."

In conformity with the foregoing act a board of officers will assemble at the Army Building, New York City, on the 13th day of July, 1881, for the purpose of making examinations of all inventions referred to in the law, and making a detailed report of such examinations, with recommendation as to what inventions are worthy of actual test, and the estimated cost of such test.

Detail for the Board.—Brevet Major-General George W. Getty, Colonel Third Artillery.
Colonel Z. B. Tower, Corps of Engineers.
Colonel J. G. Benton, Ordnance Department.
Major A. R. Buffington, Ordnance Department.
Major John Mendenhall, First Artillery.

Second Lieut. Frank E. Hobbs, Second Artillery, will report to the president of the Board for duty as recorder.

The Chief of Ordnance will furnish the Board with all the information on the subject in his possession; and all persons interested in such inventions are invited to submit to the Board plans, specifications, and models, mode of construction, cost, &c.

By command of General Sherman:

R. C. DRUM,
Adjutant-General.

Official:
H. C. CORBIN,
Assistant Adjutant-General.

Colonel J. G. Benton, Ordnance Department, died August 23, 1881, and Major F. H. Parker, Ordnance Department, was detailed as a member of the Board by the following order:

SPECIAL ORDERS No. 220.
HEADQUARTERS OF THE ARMY,
ADJUTANT-GENERAL'S OFFICE,
Washington, September 29, 1881.

[Extract.]

* * * * * * *

2. By direction of the President, Major F. H. Parker, Ordnance Department, is detailed as a member of the Board on Heavy Ordnance convened by General Orders No. 48, May 16, 1881, from this office, and will report for duty accordingly.

* * * * * * *

By command of General Sherman:

CHAUNCY McKEEVER,
Acting Adjutant-General.

Official:
H. C. CORBIN,
Assistant Adjutant-General.

The Board has continued in session, at intervals, until this date, and carefully examined and considered all inventions of heavy ordnance and improvements of heavy ordnance and projectiles presented to them, including guns now being constructed or converted under direction of the Ordnance Bureau.

These inventions and improvements have been introduced to the attention of the Board by original letters, drawings, specifications, letters patent and models, from the inventors, from the files of the Ordnance Department, and by communications from that department.

In regard to each and all of which the Board respectfully reports the following action, opinions, and recommendations, viz:

I. The following designs are regarded as *entirely impracticable*, and hence are *not recommended* for actual test:

Design for—	Submitted by—	For action, see page—
Oblong shell	W. H. Cleland	163
Heavy shot	S. Cleveland	163
Projectile	E. J. Couch	163–4
Ordnance inventions	C. B. Guy	164
Projectile	T. N. Hornsby	169
Exhausting air from bore of gun	C. B. Barrows	191

II. The following designs are *not* regarded as *having sufficient merit to warrant a trial*, and hence are *not recommended* for actual test:

Design for—	Submitted by—	For action, see page—
Gun and fortification	John Robbins	158
Guns and projectile	Joseph Harris	158
B. L. ordnance	S. C. Cobb	159
Projectile	E. L. Birchard	160
Gun construction	J. R. Tillett	162
Gun construction	John Groves	162
Cannon and projectile	J. T. Jeter	164
B. L. ordnance	Theo. Yates	168
Giving rotary motion to projectiles fired from smooth-bore guns.	M. Stafford	168
Projectile	C. Roosevelt	181
Projectiles	Dr. J. H. McLean	188

III. The following designs are *not* regarded as *within the scope of the Board's investigations*, and hence are *not recommended* for actual test:

Design for—	Submitted by—	For action, see page—
Machine gun	Jno. McNulty	158
Gun construction	A. Shroeder	158
Projectile	C. J. O'Hara	160
Artillery shell	R. M. Parker	167
Revolving cannon	J. W. Potter	161
Projectile	G. W. Turner	172
Segment shell	H. Studer	162
Projectile	A. Y. Mayer	163
Shell	A. Newport	164
Lifting machine	H. H. Sibley	167
Life-preserving rolling ship	F. M. Shields	177
Powder bags	H. Reilly	178
Segment shell	R. Woodward.	179
Elevating and depressing apparatus	A. F. Potter	160
Glass bombshell	Eastland and Bonshire	203
Claim for priority of invention of air chambers	H. Caudwell	158

IV. The following designs are *not* thought *suitable for guns of large caliber*, and hence are *not recommended* for actual test:

Design for—	Submitted by—	For action, see page—
Gun construction and carriage	Jos. Bolt	160
Gun construction	C. W. Moody	162–3
B. L. ordnance	J. R. N. Owen	163
B. L. ordnance	J. F. Quinby	163
B. L. ordnance	D. K. Swisher	163
Gun	D Fitzgerald	166
Gun and projectile	W. E. Ball	168
Gun construction	C. B. Mason	169
Gun construction	T. N. Hornsby	169

V. The following designs are *not* regarded as *suitable for use with guns of large caliber*, and hence are *not recommended* for actual test:

Design for—	Submitted by—	For action, see page—
Projectile	T. D. Gibson	160
Projectile	F. A. Markley	161
Projectile	E. W. Dunlap	162
Closing breech of gun	H. B. Anderson	164
Projectile	J. D. Richards	164
Projectile	Jos. Bolt	169
Shell	W. W. Hanes	169
Projectile	A. F. Potter	169
Port fire	G. W. Turner	172

VI. The following plans are *not recommended* for actual test, for reasons given in each case in a resolution of the Board, viz:

1. A. W. Kercheval's plan of construction:

Mr. Kercheval presents no detailed design nor description of a heavy gun or projectile for examination by the Board, nor do his general remarks offer anything specific for its consideration. His papers are therefore returned agreeably to his request.

(For action, see page 158, proceedings of the Board.)

2. F. W. Frampton's projectile:

The Board has examined the model of a projectile submitted by Mr. Frampton, and is of the opinion that in simplicity of construction and certainty of operation it is inferior to the service projectile now in use.

(For action, see page 160, proceedings of the Board.)

3. H. H. Sibley's projectile:

The Board has examined the several communications of Mr. H. H. Sibley, and the accompanying model, and is of the opinion that his proposed projectile does not possess that strength and simplicity of construction which would make it effective against armor plates and other objects of great resistance.

(For action, see page 162, proceedings of the Board.)

4. W. T. Depue's projectile:

The Board is of the opinion that the projectile proposed, being made of several parts, lacks the necessary strength and simplicity; and the form of the point is not as good as the ogival now in use.

(For action, see page 163, proceedings of the Board.)

5. D. Warner's plan for increasing the range of projectiles:

The Board has examined Mr. D. Warner's models and description of his plan for increasing the range of projectiles, and is of the opinion that it is wrong in principle.

(For action, see page 164, proceedings of the Board.)

6. J. W. Blake's system of gun construction:

In the opinion of the Board, Mr. Blake's system is not a suitable one for gun construction.

(For action, see page 169, proceedings of the Board.)

7. F. A. Dennett's projectile:

The Board having examined the plans of projectiles submitted by Mr. F. A. Dennett, is of the opinion that they possess no advantages over projectiles already in use.

(For action, see page 170, proceedings of the Board.)

8. J. Echol's plan for bursting shells containing coal gas:

Mr. Echol's plan for bursting shell is not deemed as good as the means at present employed.

(For action, see page 174, proceedings of the Board.)

9. Wm. Van Gieson's projectile:

The Board having examined the model and letters patent of a projectile for rifle cannon, submitted by Mr. Harding for Mr. Van Gieson, is of the opinion that the projectile is not as good as those already in use.

(For action, see page 177, proceedings of the Board.)

10. H. Reilly's projectile and system of rifling:

The Board * * * is of the opinion that Mr. Hugh Reilly's projectile is not any better, if so good, as those already in use, and, as it is composed of several parts, it would not be effective against armor. * * * The question of rifling is one it is not called upon to decide and could not do so without a series of experiments entirely beyond its means, and which can only be undertaken by a special board.

(For action, see page 178, proceedings of Board.)

11. Jacob Reese's process for the manufacture of steel cannon:

Mr. Reese has not presented to this Board any drawing exhibiting a plan for a gun. He recommends for gun construction steel made by the Basic in contradistinction to the acid process. His method, as described in a general way in his papers, consists in pouring molten Bessemer or other steel around a hammered steel core, 14 inches in diameter for a 12-inch gun, until the mold, giving its form, is filled. After cooling, the piece is bored. It will thus be seen that Mr. Reese's proposition is to make a cast-steel gun, which does not meet the approval of this Board.

(For action, see page 178, proceedings of the Board.)

12. W. W. Hubbell's improved system of B. L. ordnance:

Mr. Hubbell's plan of a breech fermeture, described in his letters patent and accompanying papers, is not regarded as equal to the two systems now in use. He proposes for gun construction cast iron produced by some process which, in his opinion, gives it greater tensile strength, but on this point this Board has no information. His plan for a gun is so indefinite it is presumed it is only intended to show the fermeture. In fact the Board has not before it any plan from Mr. Hubbell for a gun of suitable form and dimensions to be recommended for construction, and without further knowledge of his metal it must be looked upon as cast iron.

(For action, see page 178, proceedings of the Board.)

13. C. Dunderdale's "Ferris" system of gun construction:

The Board is of the opinion that the Ferris system of gun construction does not present any special advantages or improvements.

(For action, see pages 178–9, proceedings of the Board.)

14. S. B. Dean's gun construction and breech fermeture:

In his letters Mr. Dean does not propose to construct a gun, but rather recommends that one be constructed by the government of cast steel, prepared after the Terre Noire method. It is understood that in this process the steel, after being cast, is annealed, which is supposed to produce a similar effect to rolling or hammering. The Terre Noire steel thus made has been found excellent for projectiles, but the Board has no knowledge of its suitableness when cast in the large masses required for guns of 50 tons and upwards. Until more is known of this metal by test the Board does not recommend it for gun construction. The Board is of the opinion that Mr. Dean's plan of breech fermeture does not present any advantages over those now in use.

(For action, see page 179, proceedings of the Board.)

15. Col. T. T. S. Laidley's proposition that a cast-iron rifle-gun be tested, and:

Wm. P. Hunt's printed letter advocating the best cast iron as a metal for gun construction.

A proposition—

"that the Board select from the various projects before it of cast-iron guns, pure and simple, one that fairly represents the whole and recommend a 12-inch gun for construction and trial"—

was not adopted.

Not unanimous—two members voted in the affirmative.

(For action, see page 179, proceedings of the Board.)

16. D. Tuft's plan for B. L. ordnance:

The Board is of the opinion that Mr. Tuft's system of breech mechanism possesses no advantages over, if it is equal to, those already in use, which have been thoroughly tried.

(For action, see page 180, proceedings of the Board.)

17. R. R. Moffatt's plans for gun construction and conversion:

The Board is of the opinion that the plan of gun construction and conversion submitted by Mr. R. R. Moffatt does not present any advantages over methods now in use.

(For action, see page 181, proceedings of the Board.)

18. Norman Wiard's proposals to the Secretary of War for the construction and conversion of heavy guns.

The Board does not assent to the arguments of Mr. Norman Wiard as set forth in the various letters, papers, &c., accompanying his proposals of July 1, 1880, and March 28, 1881, referred to it, through the Chief of Ordnance, by the Secretary of War, in indorsements on letter of Mr. Wiard of the 14th of May, 1881; to show the superiority and expediency of adopting his plans of gun conversion.

(For action, see pages 181, 182, proceedings of the Board.)

19. Norman Wiard's amended proposals, dated January 2, 1882:

With regard to Mr. Norman Wiard's modifications of his proposals of the 28th of March, 1881, presented to the Board by indorsement of the Secretary of War, dated February 3, 1882, viz, dividing said proposal of March 28, 1881, into four parts, for the purpose—

1st. Of furnishing part of the powder for the tests and determining the best kind to be used for the guns referred to; the best width and depth of grooves and pitch of rifling for these guns, with original length of bores unchanged; to testing the power of these guns for penetration into iron and earth, when converted into combined rifles and smooth-bores; to apply and test the "snubbing rope" plan for checking recoil; to take velocities of all projectiles during this part of experiments, &c.

2d. To test by rapid firing the endurance of the guns referred to above.

3d. "To continue experiments to the conversion, trial, and proof of powder for the penetration of iron targets and earth works of two 15-inch smooth-bore Rodman guns into long-bore breech-loading rifled guns," &c.

4th. The furnishing of all supplies as stated in detail. * * *

The Board does not approve of the conversion of any of the smooth-bore guns now possessed by the government, and particularly does not approve of the system or systems proposed by Mr. Wiard. * * * And (referring to the Secretary of War's indorsement) the Board does not consider the form of the proposals objectionable, and therefore has no modifications to suggest.

(For action, see page 193, proceedings of the Board.)

20. Master S. Seabury's plans of gun construction, carriage, and fuze:

The gun construction for a 9-inch gun submitted by Master Samuel Seabury, United States Navy, is objectionable in several respects, principally in the fact that a large mass of steel is required for the breech-receiver, which would be difficult to make and difficult to work sufficiently, particularly in this country, to insure that homogeneity necessary for strength in that part of the construction in connection with his special fermeture; again, the breech-receiver projects unsupported beyond the body of the gun, and is thus subjected to vibration; again, the breech mechanism is similar, but not superior, to the Krupp, which this Board is not prepared to recommend. * * * The subject of gun carriages and fuzes is not within the scope of the Board's investigations.

(For action, see pages 182, 183, proceedings of the Board.)

21. The plans of gun construction, including that of the 12-inches B. L. rifles now under contract, submitted by Col. S. Crispin and Capt. C. S. Smith, Ordnance Department:

Respecting the plans of gun construction submitted by Col. S. Crispin and Capt. C. S. Smith, through the Chief of Ordnance, viz:

Two cast-iron casings with steel tube and breech receiver; one having an interrupted screw fermeture, the other a round wedge fermeture.

Three cast-iron casings with steel breech receiver; two with interrupted screw, and one with round wedge fermeture; and

Four cast-iron casings with wrought-iron tube and steel breech receiver; three with interrupted screw, and one with round wedge fermeture.

Those having combinations of wrought iron, particularly coiled wrought iron, as a lining for steel breeching and cast-iron casing are in the Board's estimation objectionable. Although the greater part of the conversions using wrought iron as a lining tube, as detailed in the yearly reports of the Chief of Ordnance, have given in small guns apparently good and encouraging results, it is on the whole, considering the history of all the guns so converted and constructed, including the 11-inch and 12.25-inch, a questionable success.

But in so expressing itself the Board desires it to be distinctly understood that it does not overlook the fact that in the small guns referred to, comparatively ineffective smooth-bores have been converted into effective rifles, deeming it simply unwise to continue the use of wrought-iron tubes, particularly for breech-loading conversions and all calibers above 8 inches, until it shall have been shown that other conversions and constructions are not what, from the most advanced views, we have a right to expect. Of those with steel breech receivers, with and without steel tubes, those having the round wedge fermeture require a breech receiver so massive that the necessary working of the metal, to give it the uniform strength required for such construction, is impracticable in this country at this time, it being the opinion of the Board that this system of fermeture requires, to compensate for the cutting away of so much metal, a highly wrought steel of homogeneous structure, the difficulties of producing which increase very rapidly with the size of the piece; and those with the interrupted screw fermeture, the breech receiver extending beyond the casing, lack its support, and may, for that reason, be defective in strength and require, like those with the wedge fermeture, a highly wrought and large piece of steel.

Resolved, In view of the objections above set forth, that this Board does not recommend any of these constructions for trial.

(For action see pages 184, 185, proceedings of the Board.)

22. Dr. J. H. McLean's system of gun construction:

The Board regards the system of gun construction presented by Dr. J. H. McLean, of Saint Louis, Mo., as exhibited in his plans and description, as defective in the following respects: That the weight of the whole gun and its parts is objectionable; that it has a multiplicity of parts, and much complex machinery; that the breech-block is much larger and heavier than those successfully and extensively now in use;

that the system is deficient in strength, and upon the whole is impracticable for heavy ordnance.

(For action, see page 188, proceedings of the Board.)

23. D. M. Mefford's plan for gun construction:

The Board does not approve of the plans of gun construction submitted by Mr. D. M. Mefford, of Toledo, Ohio.

(For action, see page 189, proceedings of the Board.)

24. A. H. Emery's plan for the conversion of smooth-bore guns:

This Board is of the opinion that the 15-inch and 10-inch guns on hand are needed for service as they are, and that it would be inexpedient to convert them into breech-loading rifles by any process. It cannot therefore recommend their conversion by the methods presented in Mr. Emery's plans.

(For action, see page 198, proceedings of the Board.)

25. Maj. S. C. Lyford's plan for gun construction:

It is the opinion of the Board that the plan for a wrought-iron gun presented by Maj. S. C. Lyford, Ordnance Department, may be practicable for the lower caliber guns, but that it is of doubtful use for those of large caliber, which it is believed can be better made of other material.

(For action, see page 203, proceedings of the Board.)

26. B. B. Hotchkiss' plan for gun construction:

The plan of a steel and wire gun designed by Mr. B. B. Hotchkiss, and presented by the Chief of Ordnance, being only of 6-inch caliber, hardly comes within the category of heavy ordnance, while the information given is very meager as to details of construction. It is submitted confidentially to the Board, which alone precludes any official consideration of, and report upon, its merits. It is therefore respectfully returned to the Chief of Ordnance.

(For action, see page 205, proceedings of the Board.)

27. Dr. W. E. Woodbridge's plan for gun construction:

The plan of an 18-inch brazed steel wire gun reinforced with wire soldered, submitted by Dr. W. E. Woodbridge, marked Plate VII, was laid aside, being of too large a caliber to warrant a recommendation for its actual test, since experiments to test the efficiency of the wire system are but just commenced with guns of 6-inch, 8-inch, and 10-inch calibers.

(For action, see page 205, proceedings of the Board.)

28. H. F. Mann's plan for gun construction and breech-mechanism:

This gun consists of a cast-iron barrel, bound around the powder chamber by steel bands. It is 30 feet in length, weighs 92,000 pounds, and is balanced on its trunnions. The breech fermeture is held to the trunnions by heavy steel straps, the whole arrangement weighing 37,000 pounds additional to the weight of the barrel, giving a total weight of 129,000 pounds. This fermeture is the characteristic feature of the gun, and is the invention of Mr. Mann. The principal objection to it is its great weight; but, further, it necessitates the turning of the barrel of the gun on its trunnions through an arc of about 10° and back again at each discharge, requiring the expenditure of more time and force than for either the Krupp-wedge or the slotted-screw systems. The piece possesses no advantages over the cast-iron gun bound with steel bands and with the screw fermeture recommended by this Board for trial, unless it be that it gives greater security against transverse rupture. Trials, however, of guns of similar construction, but with the simple screw fermeture, have proved successful within moderate limits of powder pressure—all that is claimed for the design of Mr. Mann, as is evidenced by his powder charge and weight of projectile. The only apparent merit of the structure consists in relieving the body of the gun from longitudinal strains and transferring them through the detached breech by means of steel straps to the trunnions. But in view of the objections set forth above to the fermeture itself, the specialty of Mr. Mann's invention, this Board fails to see sufficient reasons for recommending the gun for construction and trial.

(For action, see pages 206–7, proceedings of the Board.)

VII. The following designs for guns are ***not recommended*** for actual test, as the Board has preferred others of the same class for that purpose:

Design for—	Submitted by—	For action, see page—
Gun construction. Designs A, D, E, F, G, H, I, J, K, L, B$_2$, F$_2$, I$_2$. M, N, O, and P.	William P. Hunt	201-2, 206
Wire-wrapped cast-iron rifle	Col. T. T. S. Laidley	201
Cast-iron gun banded and steel gun. Plates I, III, and V.	Dr. W. E. Woodbridge	201-2, 204-5
Gun construction. Plates A$_1$, A$_2$, A$_3$, B$_1$, B$_2$, C$_1$, C$_2$, E$_1$, E$_2$, F$_1$, F$_2$, G, and K, D$_1$, and D$_2$	Chief of Ordnance	201-2
Gun construction. Plates 1, 2, 3, 4, and 5	A. H. Emery	202-3
Wire gun	Lt. C. C. Morrison	206
Steel gun, on Schultz's plan	Col. S. Crispin	206
Steel gun	L. W. Broadwell	169-70
Heavy ordnance	D. G. Smith	164

VIII. The following designs for projectiles and heavy guns are RECOMMENDED for trial in accordance with the resolution of the Board, given in each case, viz:

a. D. L. Kennedy's spiral drill-point projectile:

If at any time the Ordnance Department should be engaged in experiments to determine the penetration of different kinds of projectiles into iron, this Board recommends that Mr. Kennedy's proposed spiral projectile be also tried; but it is not deemed advisable to construct an iron target simply to test his device.

(For action, see page 193, proceedings of the Board.)

b. Paulding, Kemble & Co.'s plans of gun construction:

Messrs. Paulding, Kemble & Co.'s system of gun construction, as explained in their printed letter and accompanying drawing No. 2, has merit in common with like combinations involving a cast-iron case jacketed and hooped with steel, but in the opinion of the Board the wrought iron lining tube is objectionable. The arrangement of the contiguous parts in connection with the screw-breech closure is a good one to secure strength against fracture by longitudinal strains. The characteristic feature of this gun construction, however, seems to be the casting of the iron case in two pieces, which will effect a great saving, provided it proves efficient in strength. If any guns are made after this general system of metal combination it is recommended that the case of one be cast in two pieces for trial to test its strength.

(For action, see page 183, proceedings of the Board.)

c. Master Samuel Seabury's rifle projectile:

The Board is of the opinion that the particular merit or advantage claimed by Master Seabury for his projectile is only a matter which can be definitely determined by actual experiment, which the Board is not in a position to undertake, and while the results in Europe of the use of copper bands are sufficiently satisfactory, the details of the number of bands, their size, and the mode of attachment, as they affect the strength and ability to penetrate iron armor, should, in the opinion of the Board, be left to future experiment; and it is therefore recommended that this projectile be tried by the Ordnance Department, with others, when circumstances and opportunity are favorable.

(For action, see pages 182-3, proceedings of the Board.)

d. H. F. Mann's rifle projectile:

The particular merit claimed by Mr. Mann for his projectile is the number, position, and mode of attachment of the bands. The question how these details will affect the strength and penetrating power of the projectile can only be settled by future experiment, and it is therefore recommended that this projectile be tried by the Ordnance Department, with others, when circumstances and opportunity are favorable.

(For action, see page 207, proceedings of the Board.)

e. Paulding, Kemble & Co.'s (the improved Parrott) rifle projectile:

The improved Parrott projectile for muzzle-loading guns is recommended for actual test in connection with other projectiles in experimental or practice firing, with the 8-inch muzzle-loading rifle.

(For actions, see pages 193–4, proceedings of the Board.)

f. B. B. Hotchkiss' rifle projectile:

That, with regard to the Hotchkiss projectile submitted with letter of February 6, inclosing a tracing of it, as it is known by actual test to be a good and reliable projectile for breech-loading guns; resolved that it be recommended for further trial by the Ordnance Department.

(For action, see page 193, proceedings of the Board.)

g. Wm. P. Hunt's (the Butler) rifle projectile:

As the Butler projectile, of which drawings and description are submitted by Mr. W. P. Hunt, is known by actual trial to be a good and reliable projectile for both muzzle and breech loading guns, it is recommended for further trial in competition with other projectiles.

(For action, see page 198, proceedings of the Board.)

h. W. T. Arrick's "Eureka" rifle projectile:

Though the Arrick or "Eureka" projectile has been extensively tried, still there can be no objection to its further trial in competition with other projectiles.

(For action, see page 180, proceedings of the Board.)

i. W. E. Woodbridge's rifle projectile:

The rifle projectile proposed by Dr. W. E. Woodbridge, shown in Plate VIII, accompanying his letter of March 29, 1882, is recommended as worthy of actual test in competition with other projectiles.

(For action, see page 207, proceedings of the Board.)

k. Lieut. A. H. Russell's design for a loading pan:

The Board recommends, in the test of any piece of breech-loading ordnance with a fermeture to which it can be applied, that a device of the kind proposed by Lieutenant Russell, Ordnance Department, be tried.

(For action, see page 181, proceedings of the Board.)

l. Chief Engineer George Quick's breech-loading device:

The breech-loading device of Chief Engineer George Quick, R. N., though of doubtful superiority to other systems now extensively used abroad, yet appears to possess sufficient merit to warrant its trial, should the Ordnance Department find it convenient so to do in the construction and test of new cannon.

(For action, see page 190, proceedings of the Board.)

m. Paulding, Kemble & Co.'s breech-loading device:

The breech-loading device presented by Paulding, Kemble & Co., shown in drawing marked "Study in Ordnance," submitted by the Chief of Ordnance, with his letter dated February 6, 1882, appears to possess sufficient merit to warrant its trial, should the War Department find it proper so to do in the construction and test of new cannon.

(For action, see pages 162–3, proceedings of the Board.)

n. The "Lyman-Haskell accelerating or multicharge" cannon:

The Board recommends that the "Lyman-Haskell accelerating or multicharge" gun recently cast at Reading, Pa., be transported to Sandy Hook, and thoroughly tested under the direction of the War Department at the expense of the United States, as proposed by Mr. Haskell in his communication of October 5, 1881.

(For action, see page 181, proceedings of the Board.)

The estimated cost of the test is:

For transportation of gun from Reading, Pa., to Sandy Hook, N. J., and mounting, including all expenses incident thereto	$600 00

For test:	
Powder per round	$26 90
Projectile	28 00
Gas check, labor, &c., during test, per round	10 25
Total per round	65 15

p. Dr. W. E. Woodbridge's plan of a wire wound cast-iron gun, wire soldered (Plate II), and Plans M and H, submitted by the Chief of Ordnance:

The Board is of the opinion that the combined cast-iron and steel guns represented in the plans submitted by the Chief of Ordnance with his letters of January 17 and April 29, 1882, marked M and H, and in the plan submitted by Dr. W. E. Woodbridge with his letter of March 29, 1882, modified by letter of May 3, 1882, and marked Plate II, should be constructed and tried, for the following reasons:

1st. Experience thus far gained with similar guns promises for the combination success within usual limits of powder pressure.

2d. They can be readily and rapidly produced in this country without incurring the delay of sending to foreign countries for large masses of forged steel. The great weight of the foregoing guns recommended for test is, however, objectionable, and this Board would prefer such combinations of materials possessing the highest tensile strength as will produce, with less weight, a gun capable of giving the high velocities now sought for. But while this latter class of guns is being developed through a series of careful and costly experiments, some cheaper gun, though of less power, susceptible of rapid production, in case of need, should be determined upon, so that the country may not be left entirely defenseless.

(For action, see pages 201–2, proceedings of the Board.)

The estimated cost of the construction and test of these guns is:

For construction:	
Of gun represented by Plate II	$11,100 00
Of gun represented by Plan M	37,289 00
Of gun represented by Plan H, including $6,000 for preparation	41,170 00
Total	89,559 00

For test:	
Of gun represented by Plate II:	
Powder, per round	$25 50
Projectile	39 00
Labor, &c., during test, per round	13 10
Total per round	77 60
Of gun presented by plan M:	
Powder, per round	$76 00
Projectile	72 25
Labor, &c., during test, per round	15 75
Total, per round	164 00
Of gun represented by Plan H:	
Powder, per round	$70 89
Projectile	72 25
Labor, &c., during test, per round	15 75
Total, per round	158 89

q. The design for a 12-inch M. L. rifled mortar submitted by the Chief of Ordnance:

The Board recommends that a rifled mortar be constructed for experiment, of the caliber and dimensions proposed by the Ordnance Department, with such projectiles as that department may determine as best suited for the purpose. These mortars are very much needed for harbor defense, and emplacements for them have already been made ready at many important places on our sea-coast.

(For action, see page 202, proceedings of the Board.)

The estimated cost of the construction and test of this mortar is:

For construction	$7,148 00
For test:	
Powder, per round	$14 02
Shell	52 25
Labor, &c., during test, per round	14 50
Total, per round	80 77

r. W. P. Hunt's design (B) for a B. L. steel rifle:

This Board is of the opinion that an all-steel gun should be tested. Several of the plans for such guns presented to the Board—notably that submitted by Mr. W. P. Hunt with his letter of April 15, 1882, marked design B; that submitted by Mr. A. H. Emery, with his letter of January 23, 1882, marked Plate 5, and that submitted by Dr. W. E. Woodbridge, with his letter of March 29, 1882, marked Plate III—have undoubted merit. Of these we prefer the design of Mr. Hunt, but recommend for construction and trial a 10-inch gun after the same plan instead of the 8-inch gun shown on the drawing. Although aware that the construction of this gun is not at this time within the facilities afforded by our own manufactories, and will therefore involve the importation of the large steel tubes that go to make up the piece, we still think the gun should be tried to test the system as compared with other systems recommended, especially the forged steel and wire guns.

(For action, see pages 202-3, proceedings of the Board.)

The estimated cost of the construction and test of this gun is:

For construction (this will depend on the cost of imported steel for a trial gun) at the present rates, probably	$32,516 00
For test:	
Powder, per round	$45 90
Projectile	39 00
Labor, &c., during test, per round	13 10
Total, per round	98 00

s. Dr. W. E. Woodbridge's brazed steel wire gun, Plate VI.

A gun of 10-inch caliber, after the design of Dr. W. E. Woodbridge, was recommended for construction by the Board on Heavy Rifled Ordnance, convened by General Orders No. 57, of June 28, 1872. This device involved a steel tube to be bound around by steel wire under the requisite tension, and to be united by brazing with bronze. The gun was constructed at Frankford Arsenal, and submitted to a trial of 93 rounds, 83 of which were fired under the direction of this Board. It burst into two parts, just behind the trunnions, under a powder pressure of about 80,000 pounds to the square inch, as measured by the Rodman gauge. An examination and tests, at the Watertown Arsenal, of sections cut from the broken gun, revealed the fact that the brazing was imperfect. Several difficulties occurred in the construction of this piece from the lack of experience in applying the brazing system to so large a mass; and, further, it seems probable that undue initial strains were developed on the exterior in cooling which assisted largely in producing the transverse rupture. Could the brazing have been moderately well effected, and the interior and exterior coolings properly regulated, it is believed that the gun would have been exceptionally strong. It is a merit of this method of construction that the material is not liable to give way, causing rupture, without previous indications. The transverse crack behind the trunnions, where the rupture took place, increased during the firing by increments so minute that from the 65th to the 85th round that increase amounted to only $\frac{1}{100}$ of an inch. There could, therefore, be little if any apprehension that guns made after Dr. Woodbridge's system would burst without previous warning, though imperfectly constructed.

In view of the fact that the gun tried stood quite severe tests, notwithstanding its imperfections, and that the plant used in its construction still exists at Frankford Arsenal, it is recommended that another 10-inch gun, after the model presented by Dr. Woodbridge (Plate VI, accompanying his letter of March 29, 1882) be made for further trial. It is suggested that the method of strengthening the walls of the gun as against longitudinal strains, shown on his drawing for a 12-inch gun (Plate IV), be adopted in the construction proposed.

Not unanimous. Two members voted in the negative. (For action, see page 204, proceedings of the Board.)

The estimated cost of the construction and test of this gun is:

For construction, including alteration to "plant"	$25,500 00
For test:	
Powder, per round	$51 00
Projectile	39 00
Labor, &c., during test, per round	13 10
Total, per round	103 10

t. Design for a steel wire gun, submitted by the Chief of Ordnance:

Though the wire gun has had but a limited trial it seems to promise the strength requisite for the attainment of high initial velocities. The precise combination of parts that will give the best results for steel wire guns has not as yet been arrived at. To reach the solution of the problem it will be necessary to experiment with different gun constructions after this general method, and it is with this view that the Board recommends that the 8-inch wire gun presented by the Ordnance Department be constructed for trial.

(For action, see page 205, proceedings of the Board.)

The estimated cost of the construction and test of this gun is:

For construction	$11,400 00
For test:	
Powder, per round	$31 87
Projectile	19 60
Labor, &c., during test, per round	10 50
Total, per round	61 87

w. Dr. W. E. Woodbridge's steel gun, longitudinal bars, wire-wound, wire soldered (Plate IV):

It is the opinion of the Board that the plan of a 12-inch gun submitted by Dr. W. E. Woodbridge, Plate IV, accompanying his letter of March 29, 1882, consisting of steel tubes and bars strengthened by wire wrapped and soldered, presents a combination and arrangement of material and parts which gives sufficient promise of strength to warrant a trial of this system of construction. The large charge of powder and heavy shot proposed to be used places it in the front rank of high-power guns, and while there may be some doubt as to its ability to endure what is claimed for it, especially with the present arrangement of the two tubes, it is believed that a high-power gun can be made on this general plan, and it is with this view that the Board recommends that a 10-inch gun on this plan be made and submitted to actual test.

(For action, see page 205, proceedings of the Board.)

The estimated cost of the construction and test of this gun is:

For construction, including special "plant"	$25,000 00
For *test:*	
Powder, per round	$51 00
Projectile	39 00
Labor, &c., during test per round	13 10
Total *per round*	103 10

x. The wire-wrapped B. L. steel rifle, after the plan of Schultz, submitted by Col. S. Crispin (Plan I):

The design for a wire-wrapped B. L. steel rifle gun, after the plan of Captain Schultz, French Artillery, for securing a division of strains, presented for the consideration of this Board by Colonel Crispin, of the Ordnance Department, having already been tried abroad, with more or less success, is recommended for test, in common with the other designs of wire guns heretofore recommended, with a view to determining the best combination of parts for this general system of gun construction.

Not unanimous—one member voting in the negative. (For action, see page 206, proceedings of the Board.)

The estimated cost of the construction and test of this gun is—

For *construction* (this will depend on the cost of the steel parts and on the amount of royalty that would be claimed), probably about	$24,190 00
For *test*, assuming a weight of powder charge and projectile (the items not being given):	
Powder, per round	38 25
Projectile	33 25
Labor, &c., during test, per round	11 75
Total *per round*	83 25

In conclusion this Board presents the following brief reference to prevailing opinions and methods of gun construction as developed in the practice and experience of leading military nations during the past twenty years, and in connection therewith the considerations that have determined its recommendations for the construction and trial of the several designs for heavy guns enumerated in preceding resolutions of the Board.

The change from the former comparatively light smooth-bore gun to the heavy rifled cannon of the present day, throwing an elongated projectile of at least three times the weight of a spherical shot of the same caliber, has led to the almost entire abandonment of cast iron, unaided by other metals, for gun construction, and to the trial and adoption in its stead of metals of higher tensile strengths and elastic limits, as forged iron and steel. It is true that the Italian military authorities, and especially those of France, have experimented quite extensively with combinations of cast iron and steel for heavy guns with good results; the present naval and sea-coast armament of the latter nation being made up in great part of such guns.

It seems, however, from information at our command, that neither of these nations is disposed to rest satisfied with this combination of material for gun construction. In fact, the French have instituted trials with all steel, and recently with steel wire-wrapped guns. Herr Krupp's rifled guns are made solely of forged steel. They have been adopted in Germany, Austria, and by some of the minor powers of Europe. Though the Armstrong and Woolwich guns are constructed essentially of wrought iron, we infer from various sources that English opinion, in common with that of the continent, points to the use of steel in some shape as the future material for heavy guns both for land and naval service. The combinations of this material, as well as those of wrought iron, known as the built-up system, thus far tried with more or less success, consist of a lining tube surrounded by concentric rings or cylinders of greater or less length connected together by methods varying with the ideas of the designers, as in the Krupp, the Woolwich, and the Armstrong systems.

These different systems all agree in this, that the assemblage of parts shall produce compression upon the inner layers and extension upon the outer, so as to call forth in the most effective manner the resistance of the several rings when subjected to the strains due to the explosion of the charge.

Though long since a recognized fact that the penetration of projectiles into iron increases far more rapidly with velocity of impact than with weight of shot, it is only within a few years that changes in gun construction have been initiated looking to a large increase of initial velocities. These recent changes have involved great increase in the length of gun and in the capacity of the powder chamber, by which means about one-third additional velocity of projectile has been reached, and, notably, in the 9.45-inch Krupp gun, and in the wire-bound Armstrong gun recently constructed and tried, about one-half.

So far as we can learn, the leading military nations of the world, though already provided to some extent with guns of medium power, more or less satisfactory, are now looking for such combinations of metals as will produce a stronger gun capable of burning a very large charge of powder so as to attain the highest possible initial velocities with safety.

Steel in some form seems to be regarded as the best metal to accomplish that end. The fact that steel wire can be produced with more than twice the tensile strength of steel forged as rings has probably induced the recent construction, for trial, of wire-bound guns both in England and France. It is understood that so far as these trials have progressed the results are favorable, indicating the attainment of high velocities.

Now, the forging of the large masses from which the rings are produced by boring, that constitute the successive layers of the steel gun, involves a very expensive plant; is a very slow and costly process, and does not result uniformly in the attainment of a perfectly homogeneous metal. It would therefore be economy and probably give better results if the outer layers of the gun could be replaced by steel in a shape more readily produced and possessed of greater tensile strength. It is in part with this view that steel wire seems to have been suggested for wrapping under initial strains the interior tube and next consecutive concentric bands of the steel gun. The wire by its great tensile strength cannot fail to impart the requisite tangential strength to the structure. The only apparent difficulty of the combination is in the parts that give resistance to longitudinal strains developed in firing.

Dr. W. E. Woodbridge, who seems to have been the inventor or suggestor of the wire gun, has attempted to attain resistance to transverse rupture, other than that due to the great friction of the parts, by uniting them by brazing with bronze.

In Sir William Armstrong's wire gun, resistance to longitudinal strains is effected by the introduction of lengthwise layers of steel wire surrounding the barrel between layers of the wrapping wire, and in Schultz's gun the breech is bound to the trunnion ring by round bars of steel.

Though experiments have not yet been carried to the extent of determining the best combination of parts for this gun, within their limited range, they are so promising as to induce this Board to suggest and recommend that persistent trials be made with wire guns presenting different combinations, with a view to a full and satisfactory test of the system.

It is believed that a wire gun can be constructed with the facilities presented by the manufacturing establishments of our own country, whereas the gun built up of concentric forged steel rings is beyond those facilities as now developed, and can therefore only be produced with great delay and cost.

Though the experience of our own country has shown that heavy guns possessing moderate power can be made of cast iron solely, we do not regard it as a reliable metal for our sea-coast armament. We have, however, recommended for trial two cast-iron guns, banded with steel rings and one wrapped with steel wire, with a view to determining their suitableness for supplying, in case of urgent need, a deficiency in the armament of our forts and batteries, and with the belief that such guns can be produced at our own manufactories without much delay.

Although of the opinion that steel guns can be made of great power and endurance on the built-up principle already described, we have recommended one plan only of these guns for construction and trial, for reasons already given. Our recommendations for testing several designs of wire-wrapped guns in preference to those steel-banded are fully set forth in the foregoing remarks.

GEO. W. GETTY,
Brevet Major-General and Colonel Third Artillery.
Z. B. TOWER,
Colonel of Engineers, Brevet Major-General, U. S. A.
JOHN MENDENHALL,
Major First Artillery, Brevet Colonel, U. S. A.

The undersigned members do not subscribe to that part of the foregoing report beginning with, and following, the words, "In conclusion this Board presents the following brief reference to prevailing opinions and methods of gun construction," &c., as they cannot assent to some of the views as expressed therein.

While they believe that the correct theory of gun construction is known and generally agreed upon by experts, the best method of carrying out this theory in practice is still a subject of controversy. The diversity of opinion that exists as to the best material and form of material to be used, or the best combination of materials and the arrangement of the parts, has given rise to many systems of gun construction, the best of which, for our adoption, can only be determined by competitive trial. The reasons for the action of the Board are more or less fully given in each case, and further statement here is not thought to be necessary or advisable.

A. R. BUFFINGTON,
Lieutenant-Colonel of Ordnance.
F. H. PARKER,
Major of Ordnance.

NOTE.—The following addenda will accompany this report, viz:
I. Drawings of the guns recommended by the Board for construction and test.
II. Record of the proceedings and adjournments, including—
  A. Record of firing and star-gauging of the Woodbridge 10-inch M. L. rifle.
  B. Report on the cutting up of the Woodbridge gun and the test of specimens taken therefrom.
III. A brief description of the various inventions and plans submitted to the Board.
IV. A summary of the action taken by the Board on these inventions, plans, &c.
V. The correspondence and documentary exhibits, including all the matter laid before the Board, papers, plans, models, &c
VI. Tabular statements, summaries, and general information on the subject of gun construction laid before the Board or compiled by its direction to aid it in reaching its conclusions.

APPENDIX I.

LIST OF DRAWINGS TO THE REPORT OF THE BOARD ON HEAVY ORDNANCE AND PROJECTILES.

	Marked.
6-inch Lyman Haskell accelerating or multicharge gun	A.
10-inch cast-iron gun, wire wound, wire soldered	PLATE II.
12-inch B. L. rifle, cast-iron body, hooped with steel	M.
12-inch B. L. rifle, cast-iron body, hooped and tubed with steel	H.
12-inch M. L. rifled mortar, cast iron, hooped with steel	L.
8-inch B. L. steel rifle	DESIGN B.
10-inch brazed steel wire gun	PLATE VI.
8-inch steel wire gun	R.
12-inch steel gun, longitudinal bars, wire wound; wire soldered	PLATE IV.
9-inch wire-wrapped B. L. steel rifle	PLAN I.

F. E. HOBBS,
Second Lieutenant, Second Artillery, Recorder.

APPENDIX II.

RECORD OF THE PROCEEDINGS AND ADJOURNMENTS.

PROCEEDINGS OF A BOARD CONVENED "TO MAKE EXAMINATIONS OF ALL INVENTIONS OF HEAVY ORDNANCE AND IMPROVEMENTS OF HEAVY ORDNANCE AND PROJECTILES * * * * * INCLUDING GUNS NOW BEING CONSTRUCTED UNDER DIRECTION OF THE ORDNANCE BUREAU," IN CONFORMITY WITH THE ACT OF CONGRESS APPROVED MARCH 3, 1881, AND BY VIRTUE OF THE FOLLOWING ORDER:

HEADQUARTERS OF THE ARMY,
ADJUTANT-GENERAL'S OFFICE,
Washington, May 16, 1881.

[General Orders No. 48.]

The following order from the War Department is published for the information of all concerned:

The "act making appropriations for fortifications and other works of defense, and for the armament thereof, for the fiscal year ending June 30, 1882, and for other purposes," approved March 3, 1881, provides:

"And the President is authorized to select a Board, to consist of one Engineer officer, two Ordnance officers, and two officers of Artillery, whose duty it shall be to make examinations of all inventions of heavy ordnance and improvements of heavy ordnance and projectiles that may be presented to them, including guns now being constructed or converted under direction of the Ordnance Bureau, and said board shall make detailed report to the Secretary of War, for transmission to Congress, of such examination, with recommendation as to what inventions are worthy of actual test, and the estimated cost of such test; and the sum of twenty-five thousand dollars, or so much thereof as may be necessary, is hereby appropriated for such purpose."

In conformity with the foregoing act a Board of officers will assemble at the Army Building, New York City, on the 13th day of July, 1881, for the purpose of making examinations of all inventions referred to in the law, and making a detailed report of such examinations, with recommendation as to what inventions are worthy of actual test, and the estimated cost of such test.

Detail for the Board.—Bvt. Maj. Gen. George W. Getty, Colonel Third Artillery; Col. Z. B. Tower, Corps of Engineers; Col. J. G. Benton, Ordnance Department; Maj. A. R. Buffington, Ordnance Department; Maj. John Mendenhall, First Artillery.

Second Lieut. Frank E. Hobbs, Second Artillery, will report to the president of the Board for duty as recorder.

The Chief of Ordnance will furnish the Board with all the information on the subject in his possession; and all persons interested in such inventions are invited to submit to the Board plans, specifications, and models, mode of construction, cost, &c.

By command of General Sherman.

R. C. DRUM,
Adjutant-General.

Official:
H. C. CORBIN,
Assistant Adjutant General.

The Board met, pursuant to the foregoing order, at the Army Building, New York City, at 1 o'clock p. m., July 13, 1881.

Present: All the members and the recorder.

The order convening it having been read, the Board entered into a discussion as to the extent, meaning, and scope of the act under which it was convened, and the proper mode of disbursement of the money therein appropriated, and the president was requested to address a letter to the Adjutant-General, U. S. A., asking an interpretation of the act. (Letter-book No. 4.)

The president was also requested to ask for authority to adjourn from time to time, &c. (Letter-book No. 3.)

The Board then proceeded to the consideration and examination of plans presented to it in its correspondence, viz:

The plan and description of a gun and fortification presented by Mr. John Robbins, of Du Quoin, Ill. (L. R. No. 1); and the following resolution was unanimously adopted in reference thereto:

That the Board does not find sufficient merit in Mr. John Robbins' proposed system of gun construction to recommend it for actual test.

Mr. Robbins so informed. (Letter-book No. 6.)

The drawings and specifications of gun and projectile presented by Mr. Jos. Harris, jr., of Boston, Mass. (L. R. No. 2); and the following resolution was unanimously adopted:

That the Board does not find sufficient merit in Mr. Jos. Harris' proposed projectile or system of gun construction to recommend them for actual test.

Mr. Harris so informed. (Letter-book No. 7.)

The description by Dr. John McNulty of his "gun for sowing buckshot" (L. R. No. 3); and the following resolution was unanimously adopted:

That this paper be respectfully returned, as the matter does not come within the scope of the investigations of the Board.

Dr. McNulty informed of this resolution and his papers returned. (Letter-book No. 8.)

The statements of Mr. H. Caudwell, of Warborough, Wallingford, England (L. R. No. 4), as to the priority of his claim for the invention of air chambers; and the following resolution was unanimously adopted:

That as this is a question of priority of inventions, the Board does not regard it as within the scope of its investigations.

Mr. Caudwell so informed. (Letter-book No. 9.)

The plan of a gun invented by Mr. Alfred Schroeder, of Omaha, Nebr. (L. R. No. 5), presented by Mr. Thomas Gibson, his attorney, who was present and explained the gun to the Board. The following resolution was unanimously adopted in reference thereto:

That as it appears from the copy of letters patent submitted the system would not be applicable to heavy ordnance, the Board decides that it does not come within the scope of its investigations.

Mr. Gibson so informed. (Letter-book No. 2.)

The plan of Mr. A. W. Kercheval, of Romney, W. Va. (L. R. No. 6), for the simultaneous discharge of heavy guns and the defense of harbors; but without action thereon the Board adjourned, to meet the 14th instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, July 14, 1881.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The Board then proceeded to consider Mr. Kercheval's plans; and the following resolution was unanimously adopted:

That Mr. Kercheval presents no detailed design nor description of a heavy gun or projectile for examination by the Board, nor do his general remarks offer anything specific for its consideration. His papers are therefore returned, agreeably to his request.

Mr. Kercheval informed of this resolution and his papers returned. (Letter-book No. 10.)

A letter from Mr. N. G. Safford, of Saint Albans, Vt. (L. R. No. 7), asking for information, was read and filed.

A letter from Mr. John R. Tillet, of Manassas, Va. (L. R. No. 8), stating that his drawings, &c., would be sent to the Board, was read and filed.

A letter from Mr. D. K. Swisher, of Greenville, Ohio (L. R. No. 9), stating that his papers would be sent to the Board, was read and filed.

A letter from Mr. L. C. Cobb, of Bucyrus, Ohio (L. R. No. 11), submitting for the consideration of the Board his plans for rifling cannon, was read and laid aside for future action.

A letter from Mr. C. S. Ridgway, of Boston, Mass. (L. R. No. 10), asking when he could present his father's inventions in reference to harbor defenses and fortifications, was read and laid aside for future action.

Mr. C. W. Moody, being present, explained at length the plans and model of his breech-loading gun (L. R. No. 29). The matter was laid aside for future action.

Mr. D. Fitzgerald, of New York, being present, submitted a model and description of his gun.

The matter was laid aside for future action, and the Board then adjourned, to meet the 15th instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, July 15, 1881.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 13th and 14th instant having been read, the Board proceeded to the further consideration of Mr. L. C. Cobb's letter (L. R. No. 11); and the following resolution was unanimously adopted:

That the Board has examined the plan for rifling cannon submitted by Mr. Cobb, in his letter of July 11, 1881, and, from previous experience with a similar system, is of the opinion that it has not sufficient merit to warrant its trial.

Mr. Cobb so informed. (Letter-book No. 11.)

The Board then proceeded to the further consideration of Mr. C. L. Ridgway's letter (L. R. No. 10); and the recorder was directed to inform Mr. Ridgway that—

As the Board is only authorized to examine inventions relating to systems of manufacture and construction of heavy ordnance and projectiles, unless the invention referred to relates strictly to these things, it would not be desirable to send it on for consideration. (Letter-book No. 12.)

The consideration of Mr. Fitzgerald's design was continued; and the following resolution was unanimously adopted:

That the Board, having examined Mr. Fitzgerald's design for constructing cannon, as shown in his letter and accompanying model, is of the opinion that it is impracticable, especially for heavy cannon, and does not recommend it for test. (Letter-book No. 13.)

Mr. C. Dunderdale, of New York, personally presented and explained to the Board the plan, method of construction, &c., of the Ferris gun (L. R. No. 79). Without action the subject was laid aside for future consideration.

Mr. A. H. Emery, of New York, personally addressed the Board, requesting that it appoint some day to examine his inventions.

The Board informed Mr. Emery that he could present his plans, &c., on Wednesday, July 20.

The Board then proceeded to the consideration of subjects presented to it in its correspondence, viz:

The drawing and explanation of a projectile submitted by Mr. C. J. O'Hara, of New Orleans, La. (L. R. No. 13.)

After consideration the recorder was directed to inform Mr. O'Hara that—

Having examined his drawing and explanation the Board does not find that this matter comes within the scope of its investigations, as it refers to an incendiary composition for filling shells, rather than to a design for a projectile for heavy ordnance. (Letter book No. 14.)

The description and cut of elevating and depressing apparatus and automatic index of elevation, invented by Mr. A. F. Potter, and submitted by Mr. S. L. Cutter, of Salinas, Cal. (L. R. No. 17.)

After consideration the recorder was directed to inform Mr. Cutter that—

This matter does not come within the scope of the Board's investigations. (Letter-book No. 15.)

The model and description of a projectile, invented by Mr. A. F. Potter, and submitted by Mr. S. L. Cutter, of Salinas, Cal. (L. R. No. 16.)

After consideration the matter was laid aside for future action.

Letter from Mr. E. L. Birchard, of Susquehanna, Pa. (L. R. No. 18), submitting his model of a projectile for penetrating iron-clad vessels; and the following resolution was unanimously adopted:

That the Board, having examined the model and description given of Mr. Birchard's projectile, does not think it possesses sufficient merit to recommend it for test.

Mr. Birchard so informed. (Letter-book No. 16.)

The model and description of a projectile presented by Mr. R. M. Parker, of Rockford, Ill. (L. R. No. 19.)

The recorder was directed to inform Mr. Parker that—

As this shell is intended for field artillery its examination does not come within the scope of the Board's investigations. (Letter-book No. 17.)

The model, specification, and plan of a projectile invented and presented by Mr. F. W. Frampton, of Philadelphia, Pa. (L. R. Nos. 20 and 50); and the following resolution was unanimously adopted:

That the Board has examined the model of a projectile submitted by Mr. Frampton, and is of the opinion that, in simplicity of construction and certainty of operation, it is inferior to the present service projectiles.

Mr. Frampton so informed. (Letter book No. 18.)

The model and specification of a cannon and plan for aiming heavy guns submitted by Mr. Joseph Bolt, of Trexler, Pa. (L. R. Nos. 21 and 22.)

After consideration the recorder was directed to inform Mr. Bolt that—

The Board has examined his inventions, as shown in his letters and accompanying models, and is of the opinion that they are not suited for heavy ordnance. (Letter-book No. 19.)

The model and letters-patent of a projectile submitted by the inventor, Mr. T. D. Gibson, of Wilmington, Del. (L. R. Nos. 23 and 55.)

After examination the recorder was directed to inform Mr. Gibson that—

In the opinion of the Board his projectile is not suitable for use with heavy ordnance. (Letter-book No. 20.)

The model and letters-patent of a compound explosive projectile submitted by the inventor, Mr. F. A. Markley, of Waynesborough, Va. (L. R. Nos. 24 and 68.)

After examination the recorder was directed to inform Mr. Markley that—

In the opinion of the Board his projectile is entirely unsuited for use with heavy ordnance. (Letter-book No. 21.)

A letter from Mr. J. Reese, of Pittsburgh, Pa. (L. R. No. 25), calling attention to his process for making steel. Laid aside for future consideration.

Also letters from Mr. Reese (L. R. Nos. 26 and 42), calling attention to his process for the manufacture of steel cannon. Laid aside for future consideration.

The letters and model of a revolving cannon submitted by the inventor, Mr. J. W. Potter, of Perrysville, R. I. (L. R. No. 53.)

After examination the recorder was directed to inform Mr. Potter that—

The Board does not regard the subject of revolving cannon as within the scope of its investigations. (Letter-book No. 22.)

The model of and papers relating to the projectile invented by Mr. H. H. Sibley, of Fredericksburg, Va. (L. R. Nos. 47, 48, 49, and 77.) Laid aside for future consideration.

The Board then adjourned to meet the 19th instant, at 11 o'clock a. m.

ARMY BUILDING,
New York City, July 19, 1881.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 15th instant were read.

Mr. G. W. Turner, of Okolona, Miss., being present, explained his projectile to the Board. (L. R. No. 39.)

He was informed that as his projectile was intended for field artillery only, its consideration did not come within the scope of the Board's investigations.

The following letter from the Adjutant-General was read and filed. (L. R. No. 88):

HEADQUARTERS OF THE ARMY, ADJUTANT-GENERAL'S OFFICE,
Washington, July 18, 1881.

Bvt. Maj. Gen. GEORGE W. GETTY, U. S. A.,
President of the Board on Heavy Ordnance and Projectiles,
Army Building, New York City:

SIR: I am directed by the General of the Army to inform you that the Board on Heavy Ordnance and Projectiles, appointed in General Orders No. 48, c. s., from this office, is authorized to adjourn from time to time, and to visit such places as may be deemed expedient. The actual cost of such journeys will be paid from and charged to the appropriation of $25,000 made in the act approved March 3, 1881.

I am, sir, very respectfully, your obedient servant,

GEORGE D. RUGGLES,
Assistant Adjutant-General in charge.

Letters from Mr. J. E. Campbell, of Hamilton, Ohio (L. R. No. 59), from Mr. J. Bolt, of Trexler, Pa. (L. R. No. 63), and from Mr. A. W. Kercheval, of Romney, W. Va. (L. R. Nos. 6 and 51), were read and filed.

A letter from Dr. J. H. McLean, of Saint Louis, Mo. (L. R. No. 84), was read and filed.

The recorder was directed to inform Dr. McLean that he can submit the model, description, &c., of his cannon, when he desires. (Letter-book No. 24.)

A letter from Mr. W. W. Hanes, of Covington, Ky. (L. R. No. 74), was read and filed.

The recorder was directed to inform Mr. Hanes that he need not appear before the Board in person, but that any models, descriptions, and specifications of his inventions might be submitted if he desired. (Letter-book No. 26.)

The Board then resumed the consideration of the model of and papers relating to the projectile invented by Mr. H. H. Sibley, of Fredericksburg, Va. (L. R. Nos. 47, 48, 49, and 77); and the following resolution was unanimously adopted:

That the Board has examined the several communications of Mr. H. H. Sibley and the accompanying model, and is of the opinion that his proposed projectile does not possess that strength and simplicity of construction which would make it effective against armor plates and other objects of great resistance. It does not therefore recommend it for actual test.

Mr. Sibley so informed. (Letter-book No. 27.)

The Board then proceeded to the consideration of the matter presented to it in its correspondence, viz:

The plan and specification of an improved method of constructing ordnance, presented by Mr. J. R. Tillett, of Manassas, Va. (L. R. Nos. 8 and 37.)

The recorder was directed to inform Mr. Tillett that—

In the opinion of the Board his plan does not possess sufficient merit to warrant a recommendation for its actual test. (Letter-book No. 29.)

A plan for strengthening cast-iron guns, submitted by Mr. John Groves, of Paterson, N. J. (L. R. No. 35); and the following resolution was unanimously adopted:

That the Board has examined Mr. John Groves's plan for strengthening cast-iron guns, as set forth in his letter to the Chief of Ordnance of July 26, 1876, and does not perceive in it sufficient merit to recommend it for actual test.

Mr. Groves so informed. (Letter-book No. 30.)

The drawing of a case-shot, presented by Mr. H. Studer, of Manchester, England (L. R. No. 33); and the following resolution was unanimously adopted:

That the Board has examined the drawing of a case-shot submitted by Mr. H. Studer, of the Swiss Artillery, as set forth in his letter of June 3, 1873, to the Chief of Ordnance, and is of the opinion that his proposed projectile possesses no advantages over projectiles of this class now in the service, and, as it is designed for field artillery alone, does not come within the scope of its investigation.

Mr. Studer so informed. (Letter-book No. 32.)

The drawing of a projectile submitted by Mr. E. W. Dunlap, of Trenton, N. J. (L. R. No. 32); and the following resolution was unanimously adopted:

That the Board, having examined Mr. Dunlap's drawings, as given in his letter to the Chief of Ordnance, is of the opinion that his proposed projectile is not as well suited for ordnance of large caliber as those now in the service, and does not therefore recommend it for actual test.

Mr. Dunlap so informed. (Letter-book No. 34.)

The model, plan, and specifications of a breech system for cannon, submitted by Mr. C. W. Moody, of Indianapolis, Ind. (L. R. No. 29); and the following resolution was unanimously adopted:

That the Board has examined the description and model of Mr. C. W. Moody's breech system for ordnance, and is of the opinion that it is not well suited for cannon of large caliber. The Board does not, therefore, recommend it for actual test.

Mr. Moody so informed. (Letter-book No. 36.)

A method of loading ordnance at the breech, submitted by Mr. J. R. N. Owen, of Hamilton, Nev. (L. R. No. 36); and the following resolution was unanimously adopted:

That the Board has examined the method of loading ordnance at the breech submitted by Mr. J. R. N. Owen, and is of the opinion that it is not well suited for cannon of large caliber. The Board does not, therefore, recommend it for actual test.

Mr. Owen so informed. (Letter-book No. 38.)

Model, drawing, and description of breech-loading gun submitted by General I. F. Quinby, of Rochester, N. Y. (L. R. No. 43); and the following resolution was unanimously adopted in reference thereto:

That the Board has examined the model, drawing, and description of a breech-loading gun submitted by General I. F. Quinby, and is of the opinion that it is not well suited for guns of large caliber. The Board does not, therefore, recommend it for actual test.

General Quinby so informed. (Letter-book No. 39.)

The specifications and drawings of projectiles for field artillery, submitted by Mr. N. Y. Mayer, of Vienna, Austria. (L. R. No. 34.)

The recorder was directed to inform Mr. Mayer that this Board does not regard this matter as coming within the scope of its investigations. (Letter-book No. 40.)

The model and drawings of projectiles submitted by Mr. W. H. Cleland, of New Orleans, La. (L. R. No. 46.)

The recorder was directed to inform Mr. Cleland that—

The Board regards his plan as entirely impracticable, and does not recommend it for actual test. (Letter-book No. 41.)

The drawing of a projectile submitted by Mr. Cleveland, of Dyckesville, Wis. (L. R. No. 45.)

The recorder was directed to inform Mr. Cleveland that—

The Board is of the opinion that his method of making projectiles is entirely impracticable, and does not recommend it for actual test. (Letter-book No. 42.)

Model and description of a projectile presented by Mr. W. T. Depue, of Saint Louis, Mich. (L. R. No. 54); and the following resolution was unanimously adopted:

That the Board is of the opinion that the projectile proposed, being made of several parts, lacks the necessary strength and simplicity; and the form of the point is not as good as the ogival now in use. It does not, therefore, recommend it for actual test.

Mr. Depue so informed. (Letter-book No. 43.)

Mr. Clinton Roosevelt then appeared before the Board and read a paper for its consideration.

The Board then resumed the consideration of its correspondence, viz:

A letter from Mr. D. K. Swisher, of Greenville, Ohio (L. R. Nos. 56, 57, and 58), submitting a plan of his gun.

The recorder was directed to inform Mr. Swisher that—

The Board does not regard his plan as suitable for heavy ordnance. (Letter-book No. 45.)

The description of a magnetized steel point projectile, glazed armor plate, &c., submitted by Mr. E. J. Couch, of Grand Junction, Iowa. (L. R. Nos. 60, 61, and 62.)

The recorder was directed to inform Mr. Couch that—

The Board regards his plan as entirely impracticable, and does not, therefore, recommend it for actual test. (Letter-book No. 46.)

A plan for constructing heavy ordnance, submitted by Mr. D. G. Smith, of Carbondale, Pa. (L. R. No. 66.)

The recorder was directed to inform Mr. Smith that—

The Board does not recommend his plan for actual test. (Letter-book No. 47.)

The letters from Mr. H. B. Anderson, of Saint Louis, Mo. (L. R. Nos. 64 and 65), in reference to his inventions.

The recorder was directed to notify Mr. Anderson that—

In the opinion of the Board, his inventions are not applicable to breech-loading cannon. (Letter-book No. 48.)

The drawing and description of a projectile, submitted by Mr. J. D. Richards, of Lettsville, Iowa. (L. R. No. 69.)

The recorder was directed to inform Mr. Richards that—

His projectile is not suited for heavy ordnance. (Letter-book No. 49.)

The models and descriptions of cannon and projectiles submitted by Mr. J. F. Jeter, of Cross Plains, Ala. (L. R. No. 72.)

After consideration the following resolution was unanimously adopted:

That the Board does not find sufficient merit in Mr. Jeter's plans for cannon and projectiles to recommend them for actual test.

Mr. Jeter so informed. (Letter-book No. 50.)

The letters from Mr. A. G. Safford, of Saint Albans, Vt., submitting model of Amos Newport's shell. (L. R. Nos. 7 and 80.)

The recorder was directed to inform Mr. Safford that—

The proposed projectile being a spherical case shot, the Board does not regard this matter as coming within the scope of its investigations. (Letter-book No. 51.)

A letter from Mr. T. D. Gibson, of Wilmington, Del. (L. R. No. 81), was read and filed.

A letter from Mr. S. S. Powers, of Postville, Iowa, transmitting the ordnance inventions of Mr. C. B. Guy. (L. R. No. 82.)

After consideration the following resolution was unanimously adopted:

That the Board has examined the several small models of guns and projectiles submitted by Mr. Powers for Mr. Guy, and is of the opinion that the plans therein embodied are impracticable, and does not recommend them for actual test.

Mr. Powers so informed. (Letter-book No. 52.)

A letter from Mr. G. Leverich, of South Orange, N. J., to the president of the Board (L. R. No. 90), offering to communicate to the Board his knowledge of the Thompson gun.

The recorder was directed to inform Mr. Leverich that if his presence is desired he will be notified of the fact. (Letter-book No. 25.)

The plan proposed by Mr. D. Warner, of London, Ohio (L. R. No. 83), for increasing the range of projectiles.

After examination, the following resolution was unanimously adopted:

That the Board has examined Mr. D. Warner's models and description of his plan for increasing the range of projectiles, and is of the opinion that it is wrong in principle and does not recommend it for actual test.

Mr. Warner so informed. (Letter-book No. 54.)

The following resolution was unanimously adopted:

That the recorder be authorized to hire a clerk at a salary not to exceed $100 per month.

The Board then adjourned to meet the 20th instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, July 20, 1881.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

Mr. J. W. Buell, of Kent Cliffs, N. Y., personally appeared before the Board and submitted and explained the model of his breech system for cannon. (L. R. No. 92.)

The subject was laid aside for future consideration.

Mr. A. H. Emery, of New York, personally appeared before the Board and explained at length some of his inventions.

The proceedings of the 19th instant having been read, the Board adjourned to meet the 21st instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, July 21, 1881.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

Mr. A. H. Emery continued his remarks to the Board on the subject of his inventions.

The proceedings of the 20th instant were then read.

A letter to the president of the Board from Master Samuel Seabury, U. S. N. (L. R. No. 93), was read and filed.

The recorder was directed to inform Master Seabury that he can send his models, &c., at his convenience, and that his presence is not necessary. (Letter-book No. 56.)

Letters from Mr. Thomas D. Gibson, of Wilmington, Del. (L. R. Nos. 94 and 95), were read and filed.

The recorder was directed to inform Mr. Gibson that a report on his shell, as to its adaptability to field artillery, cannot be made, and that his model, shells, &c., will be returned to him as soon as they can be spared from the files of the Board. (Letter-book No. 57.)

A letter from Mr. Jos. Bolt, of Trexler, Pa. (L. R. No. 91), asking that the model of his "shooting machine" be transferred to the Board on small arms, was read and filed.

The recorder was directed to inform Mr. Bolt that this Board has no authority to transfer the models, &c., laid before it for its consideration. (Letter-book No. 58.)

The Board then adjourned to meet the 22d instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, July 22, 1881.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 21st instant were then read.

The following letter from the Adjutant-General of the Army was read and filed. (L. R. No. 97.)

WAR DEPARTMENT,
ADJUTANT-GENERAL'S OFFICE,
Washington, July 21, 1881.

Bvt. Maj. Gen. GEORGE W. GETTY,
President Board on Heavy Ordnance, &c.,
Army Building, New York City:

SIR: In reply to your letter of the 14th instant, I have the honor to inform you that the Secretary of War decides that the $25,000 appropriated by the act approved March

3, 1881, was to meet the current expenses of the Board and the cost of such trials as might, in the opinion of the Board, be necessary in order to gather information upon which to base the recommendations required by the act.

The Secretary concurs with the Chief of Ordnance in the opinion that this money was not intended for the final tests of inventions recommended as worthy, because such recommendations, with estimated cost of such trials, must be submitted to Congress for its action.

Very respectfully, your obedient servant,

R. C. DRUM,
Adjutant-General.

A letter from Mr. D. Tufts, of Pittsburgh, Pa. (L. R. No. 98), to Lieut. Col. A. R. Buffington, was read and filed.

The recorder was directed to notify Mr. Tufts that, as his model is quite heavy, it would be better that he submit drawings and a detailed description of his gun, and the model will be examined afterwards, if necessary. (Letter-book No. 60.)

A letter from Mr. Thomas D. Gibson, of Wilmington, Del., to the recorder (L. R. No. 96) was read and filed.

The Board suggested that the recorder reply to Mr. Gibson. (Letter-book No. 60.)

A letter from Mr. H. F. Mann, of Pittsburgh, Pa., to the President of the Board (L. R. No. 85), was read and filed.

The recorder was directed to inform Mr. Mann that he can submit his drawings, specifications, &c., as soon as practicable. If his presence is desired he will be notified. (Letter-book No. 61.)

Mr. D. Fitzgerald personally addressed the Board on the subject of his inventions (L. R. No. 30), and also presented a model of another gun.

Mr. Fitzgerald was informed that his plans were not considered suitable for guns of large caliber and could not be recommended for actual test.

Mr. Fitzgerald withdrew his models and papers (L. R. No. 30) from the files of the Board.

Mr. A. H. Emery continued his remarks to the Board on the subject of his inventions.

The Board then adjourned to meet the 26th instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, July 26, 1881.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

Mr. A. H. Emery, being present, concluded his remarks to the Board on the subject of his inventions; being plans for converting 10-inch and 15-inch guns, and constructing new guns of large caliber. Mr. Emery also made propositions to the Board in reference to certain preliminary experiments and was informed that he would be answered to-morrow, the 27th instant.

The proceedings of the 22d instant were then read.

The Board then proceeded to the consideration of its correspondence, viz:

The plans, specifications, correspondence, &c., in relation to sea-coast fortifications, and his cast-iron guns of large caliber, submitted by the Chief of Ordnance for Mr. Norman Wiard. (L. R. No. 103.)

Laid aside for future consideration.

The plans and specifications of ordnance, and an improved method of casting, submitted by Mr. William Wheeler Hubbell, of Philadelphia, Pa. (L. R. No. 102.)

Laid aside for future consideration.

A letter from Mr. G. Leverich, of South Orange, N. J., to the president of the Board (L. R. No. 99), stating what important points in regard to the Thompson gun he desires to explain to the Board, was read and filed.

A letter from Dr. J. H. McLean's secretary (L. R. No. 100), asking if Dr. McLean's presence was necessary before the Board, or whether his model should be sent, was read and filed.

The recorder was directed to inform Dr. McLean that it would be better that he submit the plans, specifications, mode of construction, and cost of his gun, and, if necessary, the model will be examined later. If his presence is necessary he will be informed of the fact. (Letter-book No. 68.)

The drawings, specifications, and patent papers of a percussion shell, submitted by Mr. W. W. Hanes, of Covington, Ky. (L. R. No. 101.)

Laid aside for future consideration.

A letter from Mr. F. W. Frampton, of Philadelphia, Pa. (L. R. No. 104), giving directions as to the disposition of his models, &c., was read and filed. (Letter-book No. 74.)

A letter from Mr. R. M. Parker, of Rockford, Ill. (L. R. No. 105), giving directions as to the disposition of his model, &c., was read and filed. (Letter-book No. 71.)

A letter from Mr. C. Dunderdale, of New York (L. R. No. 109), submitting further arguments on the Ferris gun system, read and filed with previous papers for future consideration.

Letters from Mr. William Davis, of Enfield Wash, England (L. R. Nos. 107 and 108), stating that he had sent by mail a box containing a model of a projectile he desired should be considered, were read and filed.

A letter from Mr. H. H. Sibley, of Fredericksburg, Va. (L. R. No. 106), submitting model and letters patent of Mr. E. J. Seaburn's invention for lifting and carrying heavy weights.

The recorder was directed to inform Mr. Sibley that the consideration of Mr. Seaburn's invention does not come within the scope of the Board's investigations, which are confined strictly to inventions of heavy ordnance and projectiles. (Letter-book No. 73.)

A letter from Mr. J. R. Tillett, of Manassas, Va. (L. R. No. 111), was read and filed. (Letter-book No. 62.)

A letter from Mr. Jos. Harris, of Boston, Mass. (L. R. No. 112), suggesting the idea of a gun with a bore of octagonal shape.

The recorder was directed to inform Mr. Harris that, from previous experience with similar systems of rifling, the Board does not regard the plan as having sufficient merit to warrant a recommendation for trial. (Letter-book No. 75.)

The plans and descriptions of gun, projectile, and fuse submitted by the inventor, Master Samuel Seabury, U. S. N. (L. R. No. 110.)

Laid aside for future consideration.

The Board then adjourned to meet the 27th instant, at 11 o'clock a. m.

ARMY BUILDING,
New York City, *July* 27, 1881.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 26th instant were then read.

The recorder was directed to inform Mr. Hubbell, in answer to his letter of the 23d instant (L. R. No. 102), that he can appear before the Board at any time. (Letter-book No. 76.)

The plans, description, &c., of the Ferris gun submitted by Mr. C. Dunderdale, of New York (L. R. Nos. 28, 79, 89, and 109), were considered and laid aside for future action.

Mr. Willis E. Ball, of Cold Spring, N. Y., then submitted his plans, &c., of gun and projectile (L. R. No. 113), and personally explained them to the Board.

Mr. Ball was informed by the Board that his plans were not considered applicable to heavy ordnance and projectiles, and could not be recommended for actual test. (Models and plans withdrawn by Mr. Ball.)

The model, description, and letters patent of breech-loading ordnance submitted by Mr. Theo. Yates, of Milwaukee, Wis. (L. R. No. 78), were then considered, and the following resolution was unanimously adopted:

That the Board has examined the model, description, &c., of Mr. Yates's breech-loading ordnance, and is of the opinion that the breech-loading device does not possess sufficient merit to warrant its actual test.

Mr. Yates so informed. (Letter-book No. 77.)

Mr. M. Stafford, of New York City, personally presented and explained to the Board a model of a shot of his invention, being a design to give rotary motion to projectiles fired from smooth-bore guns. He was informed that the Board did not think his plan possessed sufficient merit to warrant its test. (Model withdrawn by Mr. Stafford.)

Mr. A. H. Emery, of New York, then personally appeared, and was informed that in reference to his propositions of the 26th instant the following resolution had been unanimously adopted:

That Mr. A. H. Emery be informed that his propositions in reference to certain preliminary experiments cannot be acted upon definitely until the Board has made a more thorough examination of all the plans, projects, &c., submitted to it.

Mr. Emery addressed the Board in reference to his propositions.

The Board then adjourned to meet the 28th instant, at 11 o'clock a. m.

ARMY BUILDING,
New York City, July 28, 1881.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 27th instant were then read.

The Board then proceeded to the consideration of the matter presented to it in its correspondence, viz:

A letter from Mr. J. R. Haskell, of New York (L. R. No. 114), submitting a copy of the drawing of the 6-inch "Lyman-Haskell accelerating or multi-charge" gun, and asking how much time he could have to submit further drawings, &c.

Laid aside for future consideration, and the recorder directed to inform Mr. Haskell that he can have until October to submit his drawings, &c., and suggest that he give plans, specification, mode of construction, and cost of a 12-inch gun. (Letter-book No. 85.)

A letter from Mr. A. G. Safford, of Saint Albans, Vt. (L. R. No. 116), giving directions as to the disposition of Amos Newport's models.

Read and filed. (Letter-book No. 84.)

A letter from Mr. D. Warner, of London, Ohio (L. R. No. 117), giving directions as to the disposition of his papers.

Read and filed. (Letter-book No. 83.)

Letter from Mr. Jos. Bolt, of Trexler, Pa. (L. R. No. 116), asking for certain information.

Read and filed. (Letter-book No. 81.)

A letter from Dr. W. E. Woodbridge, of Boston, Mass. (L. R. No. 118), presenting pamphlet on his plan of gun construction.

Read and laid aside for future consideration.

A letter from Mr. Jos. Bolt, of Trexler, Pa. (L. R. No. 91), submitting model, drawing, and specification of a projectile.

The recorder was directed to inform Mr. Bolt that the Board does not think the projectile as good as canister and shrapnel now in use, and, as it is not suitable for guns of large caliber, does not recommend it for actual test. (Letter-book No. 80.)

A letter from Mr. C. B. Mason, of Sumpter, S. C. (L. R. No. 86), submitting his plan of heavy ordnance.

After examination the following resolution was unanimously adopted:

That the Board has examined the models and description of Mr. Mason's plan for construction of heavy ordnance, and not regarding it as suitable for guns of large caliber, does not recommend it for actual test.

Mr. Mason so informed. (Letter-book No. 79.)

A letter from Mr. W. W. Hanes, of Covington, Ky. (L. R. No. 101), submitting drawings, specifications, and letters patent of his percussion shell.

The recorder was directed to inform Mr. Hanes that, in the opinion of the Board, his projectile is not suitable for use with guns of large caliber. (Letter-book No. 88.)

Papers returned to Mr. Hanes as requested.

A letter from Mr. T. N. Hornsby, of Simpsonville, Ky. (L. R. No. 52), submitting plans and description of projectile and scroll gun.

After consideration the following resolution was unanimously adopted:

That the Board has examined the models, plans, and description of a projectile and scroll gun submitted by Mr. Hornsby, and, from experience with similar projectiles, is of the opinion that his plan for giving rifled motion is impracticable. The system of gun construction is not thought to be applicable to guns of large caliber, and is not therefore recommended for actual test.

Mr. Hornsby so informed. (Letter-book No. 86.)

A letter from Mr. J. W. Blake, of Marshall, Minn., transmitted by Hon. William Windom (L. R. No. 44), inclosing description of his system of gun construction.

After consideration the following resolution was unanimously adopted:

That, in the opinion of the Board, Mr. Blake's system is not a suitable one for gun construction, and is not recommended for actual test.

Mr. Blake so informed. (Letter-book No. 89.)

The model and description of a projectile invented by Mr. A. F. Potter, and submitted by Mr. S. L. Cutter, of Salinas, Cal. (L. R. No. 16), taken up for further consideration, and the following resolution was unanimously adopted:

That the Board, having examined Mr. Potter's projectile, is of the opinion that it is not suitable for use with guns of large caliber.

Mr. Cutter so informed. (Letter-book No. 90.)

A letter from Mr. L. W. Broadwell, of Döbling, Austria (L. R. No. 31), transmitted to the Board by the Chief of Ordnance, giving tracing and description of 11-inch steel built up B. L. rifled gun.

After consideration the following resolution was unanimously adopted:

That the Board does not recommend Mr. Broadwell's plan for actual test.

Mr. Broadwell so informed. (Letter-book No. 91.)

A letter from Mr. S. B. Dean, of Boston, Mass. (L. R. No. 75), submitting plans and description of his gun.

Laid aside for future consideration.

A letter from Mr. F. A. Dennett, of Boston, Mass. (L. R. Nos. 38 and 76), submitting plans and description of his projectile.

After consideration the following resolution was unanimously adopted:

That the Board, having examined the plans of projectiles submitted by Mr. F. A. Dennett, is of the opinion that they possess no advantages over projectiles already in use, and does not therefore recommend them for actual test.

Mr. Dennett so informed. (Letter-book No. 92.)

Mr. Norman Wiard's plans, specifications, correspondence, &c., in relation to sea-coast fortifications and heavy guns (L. R. No. 103) were taken up, but, without completing their consideration, the Board adjourned to meet the 29th instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, July 29, 1881.

The Board met, pursuant to adjournment, at 11 o'clock a m.

Present: All the members and the recorder.

The proceedings of the 28th instant were then read.

A letter from Mr. H. F. Mann, of Pittsburgh, Pa. (L. R. No. 119), was read and filed.

The recorder was directed to inform Mr. Mann that unless he can appear before the Board next week he had better defer his visit until after the 1st of October. (Letter-book No. 93.)

A letter from Mr. H. H. Sibley, of Fredericksburg, Va. (L. R. No. 120), giving directions as to the disposition of Mr. Seaburn's model, was read and filed.

The consideration of Mr. Norman Wiard's plans, propositions, &c., was continued and the papers finally laid aside for future consideration.

After an extended discussion on various plans for future action, the Board adjourned to meet the 1st proximo at 11 o'clock a. m

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ARMY BUILDING,
New York City, August 1, 1881.

The Board met, pursuant to adjournment, at 11.15 o'clock a. m.

Present: All the members and the recorder.

Mr. William Wheeler Hubbell, of Philadelphia, Pa., personally addressed the Board on the subject of his method of making cast iron for gun construction and his breech-loading ordnance.

The proceedings of the 29th ultimo were then read.

A letter from Mr. C. J. O'Hara, of New Orleans, La. (L. R. No. 124), claiming great superiority of his shell, was read and filed.

A letter from Mr. C. W. Moody, of Indianapolis, Ind. (L. R. No. 125), submitting further arguments in favor of his gas check, was read and filed.

The recorder was directed to inform Mr. Moody that the Board adheres to its decision, in regard to his inventions, communicated to him in letter of the 20th ultimo. (Letter-book No. 98.)

Letters from Mr. Theo. Yates, of Milwaukee, Wis. (L. R. No. 123), and from Mr. F. W. Frampton, of Philadelphia, Pa. (L. R. No. 122), giving directions as to the disposition of their models, &c., were read and filed. (Letter-book Nos. 97 and 99.)

The Board then proceeded to the consideration of Mr. Hubbell's plans as set forth in his letters patent, pending which the Board adjourned to meet the 2d instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, August 2, 1881.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 1st instant were then read.

Mr. D. L. Kennedy, of New York City, submitted a model of his spiral drill-pointed projectile (L. R. No. 127), and personally explained its features and advantages to the Board.

The matter was laid aside for future consideration.

Mr. R. R. Moffatt, of Brooklyn, N. Y., personally submitted the drawings and descriptions of his plan of heavy ordnance construction (L. R. No. 126) and explained them to the Board.

The matter was laid aside for future consideration.

The letters from Mr. J. Reese, of Pittsburgh, Pa. (L. R. Nos. 25 and 26), were taken up for further consideration, and the recorder was directed to request Mr. Reese to submit definite plans and information to the Board. (Letter-book No. 100.)

After further general discussion of the plans before it, the Board adjourned to meet the 3d instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, August 3, 1881.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

Dr. W. E. Woodbridge, of Boston, Mass., personally appeared before the Board and explained at length the plan and method of constructing his 10-inch M. L. rifled wire gun.

The Board then adjourned to meet the 4th instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, August 4, 1881.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 2d and 3d instant were then read.

After some general discussion of the various plans before it, the following resolution was unanimously adopted:

That, in view of the proposition of Colonel Laidley, the Chief of Ordnance be asked to furnish this Board all information—that is, history, records of firing, pressures, velocities, &c.—relative to and tests for endurance of cast-iron guns, especially rifled guns of 8-inch caliber and upwards; also any reports of and experiments made by Colonel Laidley to test the value of cast iron as a material for heavy construction. (Letter-book No. 101.)

Dr. W. E. Woodbridge, of Boston, Mass., personally appeared before the Board and exhibited and explained drawings of a projectile of his invention.

The Board then continued the consideration of Dr. Woodbridge's gun, and the following resolution was unanimously adopted:

That the Woodbridge 10-inch M. L. rifle, now at Sandy Hook, N. J., in possession of the Ordnance Department, be fired under supervision of the Board at least 100 rounds—records giving measurements of bore, velocities, pressures, &c., being kept—in order that it may obtain all possible information before action on the system proposed by Dr. Woodbridge; and that the Chief of Ordnance be requested to extend to the Board all necessary facilities for conducting the aforesaid experiments at Sandy Hook proving grounds, the expense of the same to be paid for out of the money appropriated for that purpose. (Letter-book No. 102.)

The Board then adjourned to meet the 5th instant, at 11 o'clock a. m.

ARMY BUILDING,
New York City, August 5, 1881.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 4th instant were then read.

A letter from Mr. C. B. Mason, giving directions as to the disposition of his model (L. R. No. 131), was read and filed.

Mr. A. H. Emery, of New York, then addressed the Board in regard to his propositions for the comparative test of systems of gun construction, and the following resolution was unanimously adopted:

Resolved, That the Board obtain from Mr. A. H. Emery, of New York, drawings of ten different systems of heavy gun construction, each giving section of entire gun through axis, and sections of one and one-half calibers in length at six different points; also, section of a model of the breech for machine and powder test, as explained and shown in drawing exhibited this day; and also an approximate estimate of the cost of the models and sections made after the drawings; and that the sum of $1,000—$100 per set—be paid for said drawings and estimates out of the money appropriated for the expenses of the Board.

Mr. Emery informed of this resolution and requested to state whether he can make the drawings and estimates on the terms mentioned, and when they will be furnished. (Letter-book No. 104.)

The Board then adjourned to meet the 9th instant, at 11 o'clock a. m.

ARMY BUILDING,
New York City, August 9, 1881.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 5th instant were then read.

A letter from Mr. G. W. Turner, of Okolona, Miss. (L. R. No. 132), transmitted to the Board by the Chief of Ordnance, was read, and, after consideration of the model and description, the recorder was directed to inform Mr. Turner that his projectile is not regarded as suitable for use with guns of large caliber, and that the subject of port-fires is not within the scope of the Board's investigations. (Letter-book No. 111.)

A letter from Dr. J. H. McLean, of Saint Louis, Mo. (L. R. No. 133), stating that he had made arrangements with the South Boston Iron Company to receive the model and drawings of his 100-ton gun, was read and filed.

The recorder was directed to inform Dr. McLean that the Board would probably visit the South Boston Foundry some time in October, and would then examine his model, &c. (Letter-book No. 117.)

A letter from Mr. J. W. Blake, of Marshall, Minn. (L. R. No. 135), asking how long the Board would be in session, was read and filed.

The recorder was directed to inform Mr. Blake that the Board will adjourn to-day, to meet again the 5th of October, in this city. (Letter-book No. 118.)

Letters from Mr. J. W. Blake, of Marshall, Minn. (L. R. No. 134); from Mr. F. A. Dennett, of Boston, Mass. (L. R. No. 136); and from Mr. Jos. Bolt, of Trexler, Pa. (L. R. No. 139), giving directions as to the disposition of their drawings and papers, were read and filed. (Letter-book Nos. 119, 120, 112.)

Mr. A. H. Emery, of New York, then addressed the Board in regard to the drawings to be made by him, and accepted the proposition of the Board. (L. R. No. 137.)

A list giving the ten systems of gun construction, of which drawings were to be made, was given Mr. Emery. (Letter-book No. 108.)

The Board then adjourned, to meet the 5th of October.

ARMY BUILDING,
New York City, October 5, 1881.

The Board met, pursuant to adjournment, at 11.15 o'clock a. m.

Present: All the members, except Col. J. G. Benton, deceased. The recorder also present.

The original order convening the Board was then read, and also the following order:

[Special Orders, No. 220.]

HEADQUARTERS OF THE ARMY,
ADJUTANT-GENERAL'S OFFICE,
Washington, September 29, 1881.

[Extract.]

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2. By direction of the President, Maj. F. H. Parker, Ordnance Department, is detailed as a member of the Board on Heavy Ordnance, convened by General Orders, No. 48, May 16, 1881, from this office, and will report for duty accordingly.

* * * * * * *

By command of General Sherman.

CHAUNCEY McKEEVER,
Acting Adjutant-General.

Official:
H. C. CORBIN,
Assistant Adjutant-General.

The proceedings of August 9 were then read.

The following letters, received during the adjournment of the Board, were read and filed, viz:

From the Chief of Ordnance (L. R. No. 140), in reply to the Board's letter of August 4.

From Mr. H. F. Mann, of Pittsburg, Pa. (L. R. No. 143), stating that he would appear before the Board on its reassembling.

From the Chief of Ordnance (L. R. No. 145), stating that Colonel Baylor had been given instructions to make the necessary arrangements for the trial, by the Board, of the Woodbridge 10-inch M. L. rifle.

From Mr. H. Caudwell, of Warborough, England (L. R. No. 148), asking that his previous papers be reconsidered.

From Dr. J. H. McLean, of Saint Louis, Mo. (L. R. Nos. 149, 153, and 160), stating that the drawings of his 100-ton gun (Hercules) and working model of a gun built on his system are at the South Boston Iron Foundry for the inspection of the Board, and desiring to be informed when the Board visits that place.

From the Chief of Ordnance (L. R. No. 155), stating that certain books containing information asked for in the Board letter of August 10, now at the New York Agency, are placed temporarily at the disposal of the Board.

From Mr. George Walker, consul-general at Paris, France (L. R. No. 159), transmitting certain information in reference to heavy ordnance of France.

From Mr. H. Caudwell, of Warborough, England (L. R. No. 162), in reference to his former communications.

Letters from Mr. J. Reese, of Pittsburgh, Pa. (L. R. No. 138), and from Mr. W. W. Hubbell, of Philadelphia, Pa. (L. R. No. 151), were read and laid aside for future consideration.

A letter from Mr. J. Echols, of Lynchburg, Va. (L. R. No. 146), submitting a plan for bursting shells containing coal gas, was read and considered.

The recorder was directed to inform Mr. Echols that his plan for bursting shell, not being deemed as good as the means at present employed, is not recommended for actual test. (Letter-book No. 160.)

A letter from Mr. W. Davis, of Enfield Wash, England (L. R. No. 156), relative to the model of his projectile, was read and filed. (Letter-book No. 161.)

A letter from Lieut. Col. S. Crispin, Ordnance Department (L. R. No. 144), inclosing blue prints of the plan of gun construction adopted by the Ordnance Department for the four 12-inch rifles, and several modifications of the same, with general remarks regarding each plan, &c., transmitted to the Board by the Chief of Ordnance, was then read and laid aside for future consideration.

Letter from the Chief of Ordnance (L. R. No. 150), transmitting Senate Ex. Doc. No. 4 of the special session, and a report by Capt. C. S. Smith, Ordnance Department, as requested in the Board letter of August 4; and a letter from Mr. D. Tufts, of Pittsburgh, Pa. (L. R. No. 142), transmitting drawings and description of his gun, were read and laid aside for future consideration.

Mr. A. H. Emery then exhibited seven completed drawings of gun construction, &c., of the ten to be prepared by direction of the Board, and addressed the Board at length in reference thereto.

The Board then adjourned, to meet the 6th instant, at 11 o'clock a. m.

ARMY BUILDING,
New York City, October 6, 1881.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 5th instant were then read.

Mr. J. R. Haskell, of New York, then addressed the Board at length, in reference to the "Lyman-Haskell accelerating or multi-charge" gun. (L. R. No. 164.)

The Board then adjourned, to meet the 7th instant, at 11 o'clock a. m.

ARMY BUILDING,
New York City, October 7, 1881.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 6th instant were then read.

A letter from Lieut. A. H. Russell, Ordnance Department (L. R. No. 166), stating that he had forwarded to the Board a model of a loading pan for use with the French system of fermeture, and offering to furnish drawings, was read and filed.

The recorder was directed to request Lieutenant Russell to furnish the drawings. (Letter-book No. 165.)

After discussion, the Board adjourned, to meet the 11th instant, at Sandy Hook proving ground, New Jersey.

SANDY HOOK, N. J.,
October 11, 1881.

The Board met, pursuant to adjournment, at 4.30 o'clock p. m.

Present: General Getty, Major Parker, and the recorder.

Absent: Colonel Tower, Lieutenant-Colonel Buffington, and Major Mendenhall; by authority of the Board.

A programme for the firing of the Woodbridge 10-inch M. L. rifled gun having been agreed upon, the Board adjourned, to meet the 12th instant.

SANDY HOOK, N. J.,
October 12, 1881.

The Board met, pursuant to adjournment.

Present: General Getty, Major Parker, Major Mendenhall, and the recorder.

Absent: Colonel Tower, and Lieutenant-Colonel Buffington; by authority of the Board.

The firing of the Woodbridge gun was commenced, and, fifteen rounds having been fired, the Board adjourned, to meet the 13th instant.

SANDY HOOK, N. J.,
October 13, 1881.

The Board met, pursuant to adjournment.

Present: General Getty, Major Parker, Major Mendenhall, and the recorder.

Absent: Colonel Tower and Lieutenent-Colonel Buffington; by authority of the Board.

The firing of the Woodbridge gun was continued, and twenty rounds having been fired, the Board adjourned, to meet the 14th instant.

SANDY HOOK, N. J.,
October 14, 1881.

The Board met, pursuant to adjournment.

Present: General Getty, Colonel Tower, Major Parker, Major Mendenhall, and the recorder.

Absent: Lieutenant-Colonel Buffington; by authority of the Board.

The firing of the Woodbridge gun was continued, and, twenty rounds having been fired, the Board adjourned, to meet the 15th instant.

SANDY HOOK, N. J.,
October 15, 1881.

The Board met, pursuant to adjournment.

Present: General Getty, Major Mendenhall, and the recorder.

Absent: Colonel Tower, Lieutenant-Colonel Buffington, and Major Parker; by authority of the Board.

The firing of the Woodbridge gun was continued, and, thirteen rounds having been fired, the Board adjourned, to meet the 17th instant.

SANDY HOOK, N. J.,
October 17, 1881.

The Board met, pursuant to adjournment.

Present: General Getty, Major Parker, Major Mendenhall, and the recorder.

Absent: Colonel Tower and Lieutenant-Colonel Buffington; by authority of the Board.

The firing of the Woodbridge gun was continued, and seven rounds having been fired, the Board adjourned, to meet the 18th instant.

SANDY HOOK, N. J.,
October 18, 1881.

The Board met, pursuant to adjournment.

Present: General Getty, Colonel Tower, Major Parker, Major Mendenhall, and the recorder.

Absent: Lieutenant-Colonel Buffington; by authority of the Board.

The firing of the Woodbridge gun was continued.

Eight rounds having been fired, the gun burst—a total of ninety-three rounds—ten at Frankford Arsenal, and eighty-three at Sandy Hook, under the supervision of the Board.

The record of firing, with notes, is appended to the record, marked "A."

The Board then adjourned, to meet in New York City at 11 o'clock a. m. on the 20th instant.

ARMY BUILDING,
New York City, October 20, 1881.

The Board met, pursuant to adjournment, at 11.20 o'clock a. m.

Present: All the members and the recorder.

The Board then proceeded to the consideration of its correspondence, and the following letters were read and laid aside for future consideration, viz:

From Lieut. A. H. Russell, Ordnance Department, U. S. A. (L. R. No. 182), inclosing description and drawing of his loading pan for use with the interrupted screw system of breech fermeture, as requested by the Board, in letter of the 7th instant.

From Mr. S. B. Dean, of Boston, Mass. (L. R. No. 173), submitting model and drawing with further description of his steel gun. (Filed with previous papers.)

From Mr. W. P. Hunt, of Boston, Mass. (L. R. No. 174), submitting copies of a letter explaining his views on gun construction, with drawings.

A letter from General L. Richmond, United States consul at Rome, Italy (L. R. No. 176), transmitting copies of "L'Italia Militare," containing an article on the gun construction of Italy, was read and filed for reference.

A letter from Mr. D. M. Mefford, of Toledo, Ohio (L. R. No. 172), submitting a system of gun construction.

Read and laid aside to wait further communication from Mr. Mefford.

A letter from Mr. F. C. Smink, of Reading, Pa. (L. R. No. 177), inviting the Board to witness the casting of the Lyman-Haskell gun, on October 24, 1881.

Read, and Mr. Haskell, who appeared before the Board to urge the acceptance of the invitation, was informed verbally that the Board could not accept.

A letter from Mr. F. M. Shields, of Coopwood, Miss. (L. R. No. 169), submitting plan, specification, and description of his "life-preserving rolling ship," was read, and the recorder directed to inform Mr. Shields that the consideration of this matter does not come within the scope of the Board's investigations, which are confined strictly to inventions of heavy ordnance and projectiles. (Letter-book No. 176.)

A letter from Mr. Wm. A. Harding, of New York City (L. R. No. 175), submitting model and letters patent of Mr. Wm. Van Gieson's projectile for rifled ordnance, was read, the model and description examined, and the following resolution unanimously adopted:

That the Board having examined the model and letters patent of a projectile for rifled cannon, submitted by Mr. Harding for Mr. Van Gieson, is of the opinion that the projectile is not as good as those already in use. It does not therefore recommend it for actual test.

Mr. Harding so informed. (Letter-book No. 177.)

One of the members of the Board being under orders to change station, and the recorder having been ordered, with others, to appear before a board of ordnance officers for examination, with view to a selection for transfer to the Ordnance Department, the Board then adjourned, to meet the 16th of November.

ARMY BUILDING,
New York City, November 16, 1881.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

Mr. H. F. Mann then presented his system of gun construction to the Board, the argument in favor of its test being made by Professor Thurston, his attorney. Models, plans, and specifications withdrawn for a few days by Mr. Mann to enable him to print the argument and present the matter complete.

The proceedings of October 20 were then read, and the Board proceeded to the consideration of its correspondence, as follows:

Copies of the letter written by the president of the Board to the Adjutant-General of the Army, asking that steps be taken to obtain through the State Department information in regard to recent French and Italian gun constructions, were then read. (Letter-book Nos. 179 and 180.)

A letter from the Adjutant-General of the Army (L. R. No. 195), furnishing copies of letter of the honorable the Secretary of War and reply of the honorable the Secretary of State, relative to information regarding heavy ordnance of France, was read and filed.

A letter with plans from Paulding, Kemble & Co., Cold Spring, N. Y. (L. R. No. 194), submitting ideas in gun construction, and asking consideration of the improved Parrott projectile, was read and laid aside for future action.

The Board then adjourned, to meet the 17th instant, at 11 o'clock a. m.

ARMY BUILDING,
New York City, November 17, 1881.

The Board met pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 16th instant were then read, and the Board proceeded to the consideration of the business before it.

A letter from Mr. H. F. Mann, of Pittsburgh, Pa. (L. R. No. 196), asking whether his 8.4-inch gun is before the Board, was read, and the recorder directed to reply that it is. (Letter-book No. 187.)

A letter from Dr. W. E. Woodbridge (L. R. 198), asking that specimens for examination and test be cut from his gun, and giving reasons therefor, was read, and the recorder directed to ask Dr. Woodbridge to furnish an estimate of the cost of the work. (Letter-book No. 189.)

A letter from Mr. Hugh Reilly, of New York (L. R. No. 197), submitting models of his inventions of cartridge-bags, projectiles, and plan for rifling cannon, with letters patent in each case, and argument in favor of their adoption, was then read; and, after consideration, the following resolution was unanimously adopted:

That the Board, having carefully examined the several inventions of Mr. Hugh Reilly, is of the opinion that his projectile is not any better if so good as those already in use, and, as it is composed of several parts, it would not be effective against armor. The subject of cartridge-bags is not within the scope of its investigations. The question of rifling is one it is not called upon to decide, and could not do so without a series of experiments entirely beyond its means, and which can only be undertaken by a special board.

Mr. Reilly so informed. (Letter-book No. 185.)

The following resolution was then adopted unanimously:

Resolved, That the Board now take up for final discussion and disposition, and in the order in which set aside for future consideration, each project or invention now before it.

The propositions of Mr. J. Reese, of Pittsburgh, Pa. (L. R. Nos. 25, 26, 42, and 138), were then taken up for final consideration, and the following resolution unanimously adopted:

That Mr. Reese has not presented to this Board any drawing exhibiting a plan for a gun. He recommends for gun construction steel made by the Basic in contradistinction to the acid process. His method, as described in a general way in his papers, consists in pouring molten Bessemer or other steel around a hammered steel core 14 inches in diameter for a 12-inch gun until the mold, giving its form, is filled. After cooling, the piece is bored. It will thus be seen that Mr. Reese's proposition is to make a cast-steel gun, which does not meet the approval of this Board.

The plans proposed by Mr. W. W. Hubbell (L. R. Nos. 41, 102, and 151) were then taken up for final consideration, and the following resolution unanimously adopted:

That Mr. Hubbell's plan of a breech fermeture, described in his letters patent and accompanying papers, is not regarded as equal to the two systems now in use. He proposes, for gun construction, cast iron produced by some process which, in his opinion, gives it greater tensile strength, but on this point this Board has no information. His plan for a gun is so indefinite, it is presumed it is only intended to show the fermeture. In fact, the Board has not before it any plan from Mr. Hubbell for a gun of suitable form and dimensions to be recommended for construction; and without further knowledge of his metal, it must be looked upon as cast iron.

The Ferris system of gun construction, submitted by Mr. C. Dunderdale, of New York City (L. R. Nos. 28, 79, 89, and 109), was taken up for final consideration, and the following resolution was unanimously adopted:

That the Board is of the opinion that the Ferris system of gun construction does not present any special advantages or improvements, and in consequence it does not recommend it for actual test.

The plans for a gun submitted to this Board by Mr. S. B. Dean, of Boston, Mass. (L. R. Nos. 75 and 173), with his drawing and explanations, were then taken up and discussed, and the following action taken thereon:

In his letters Mr. Dean does not propose to construct a gun, but rather recommends that one be constructed by the government, of cast steel prepared after the Terre Noire method. It is understood that in this process the steel after being cast is annealed, which is supposed to produce a similar effect to rolling or hammering. The Terre Noire steel thus made has been found excellent for projectiles, but the Board has no knowledge of its suitableness when cast in the large masses required for guns of 50 tons and upwards. Until more is known of this metal by test the Board does not recommend it for gun construction. The Board is of the opinion that Mr. Dean's plan of breech fermeture does not present any advantages over those now in use, and therefore it is not recommended for actual test.

The Board then adjourned to meet the 18th instant, at 11 o'clock a. m.

ARMY BUILDING,
New York City, November 18, 1881.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 17th instant were then read.

Mr. Robert Woodward personally presented a drawing of a segment shell for field artillery, but, on being informed by the Board that the subject was not within the scope of its investigations, withdrew.

The proposition of Col. T. T. S. Laidley, Ordnance Department (L. R. No. 87), that a cast-iron rifled gun be tested, and the letter of Mr. Wm. Hunt, on the "construction of ordnance" (L. R. No. 174), both advocating the best cast iron as a material for gun construction, were then taken up for final consideration, and, after discussion, the following resolution was proposed:

That the Board select from the various projects before it of cast-iron guns, pure and simple, one that fairly represents the whole, and recommend a 12-inch gun for construction and trial.

The resolution was not adopted.

Noes.—Major Mendenhall, Colonel Tower, and General Getty—3.

Ayes.—Major Parker and Lieutenant-Colonel Buffington—2.

Lieutenant-Colonel Buffington and Major Parker gave the following reasons for their votes:

1st. The experiment would not be costly, and there are improved methods of casting claimed to remove certain weaknesses inseparable from cast-iron guns.

2d. Powders and projectiles have been improved to give more uniform results and less destructive effects on guns.

3d. It is only by actual test of a large gun under these improved conditions that the suitability of cast iron for heavy ordnance can be known and its comparative merits with other metals and systems of gun construction determined.

4th. The trial of a cast-iron gun, pure and simple, may furnish useful information in regard to cast iron in combination with other metals.

After further discussion of this subject the Board adjourned to meet the 21st instant, at 11 o'clock a. m.

ARMY BUILDING,
New York City, November 21, 1881.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 18th instant were then read.

The discussion of the subject of cast-iron rifled guns was continued.

As requested by Mr. H. F. Mann, in his letter of the 9th instant (L. R. No. 193), the Board obtained from the Ordnance Board a copy of his letter of June 21, 1878, and the indorsement of the Ordnance Board thereon. (L. R. No. 203.)

Read and filed.

A letter from Mr. G. Leverich, of South Orange, N. J. (L. R. No. 199), asking whether the 12-inch Thompson rifle would be tested, and protesting against any changes in the present breech mechanism, was read, and the recorder directed to inform Mr. Leverich that the Board has not taken up the gun for consideration, and should it be decided to try the gun, he will be informed of the fact. (Letter-book No. 191.)

A letter from Mr. W. T. Arrick, attorney, Washington, D. C. (L. R. No. 200), submitting letters patent of the "Eureka" projectile for the consideration of the Board, was read; and, after careful consideration, the following resolution was unanimously adopted:

Though the Arrick or "Eureka" projectile has been extensively tried, still there can be no objection to its further trial in competition with other projectiles.

A letter from Capt. W. S. Starring, Ordnance Department, U. S. A. (L. R. No. 202), transmitting photographs showing end views of rupture of the Woodbridge 10-inch rifle, was read and filed.

A letter from Dr. W. E. Woodbridge (L. R. No. 201), in answer to the Board letter of the 18th instant, stating how he desires his gun cut up, and giving estimate of cost of the work, was read and filed.

Mr. A. H. Emery, of New York, then addressed the Board, explaining the drawings of systems of gun construction ordered from him.

The Board then adjourned to meet the 22d instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, November 22, 1881.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 21st instant were then read.

A letter from Mr. H. F. Mann (L. R. No. 204), requesting that he be informed if any tests of his 8.4-inch gun are to be made, was read and filed.

The plan of a breech-loading gun submitted by Mr. D. Tufts, of Pittsburgh, Pa. (L. R No. 142), was then taken up for final consideration, and the following resolution was unanimously adopted:

That the Board is of the opinion that Mr. Tuft's system of breech mechanism possesses no advantages over, if it is equal to, those already in use, which have been thoroughly tried, and therefore does not recommend it for actual test.

The projectile presented by Mr. Clinton Roosevelt (L. R. No. 129), was then taken up for final consideration, and the following resolution unanimously adopted:

That the projectile presented by Mr. Roosevelt, intended to be fired from a smooth bore gun, and to attain rotary motion by the action of the atmosphere on radial wings or flanges, does not present sufficient merit to warrant the Board in recommending it for actual test.

The plans of gun construction and conversion presented by Mr. R. R. Moffatt, of Brooklyn, N. Y. (L. R. No. 126), were then taken up for final consideration, and the following resolution unanimously adopted:

That the Board is of the opinion that the plan of gun construction and conversion submitted by Mr. R. R. Moffatt does not present any advantages over methods now in use, and the Board does not, therefore, recommend it for actual test.

The plans of gun construction, including that of the proposed 12-inch B. L. rifles, submitted by Capt. C. S. Smith, Ordnance Department (L. R. No. 67), and by Col. S. Crispin, Ordnance Department (L. R. No. 144), were taken up for consideration, but laid aside for future action.

The plan of a loading pan proposed by Lieut. A. H. Russell, Ordnance Department (L. R. Nos. 166 and 182), was taken up for final consideration, and the following resolution was unanimously adopted:

That the Board recommends, in the test of any piece of B. L. ordnance with a fermeture to which it can be applied, that a device of the kind proposed by Lieutenant Russell, Ordnance Department, be tried.

Mr. Norman Wiard's plans, specifications, correspondence, &c., in relation to sea-coast fortifications and heavy guns (L. R. No. 103), were taken up for consideration, but laid aside until the next meeting of the Board.

The plans of gun construction, projectile, fuze, and carriage submitted by Master S. Seabury, United States Navy (L. R. Nos. 110 and 121), were taken up for consideration, but laid aside for future action.

The plan of gun construction proposed by Mr. J. R. Haskell, of New York City (L. R. Nos. 40, 114, and 164), with the accompanying drawings and descriptions, was then taken up for final consideration, and the following resolution was unanimously adopted:

That the Board recommends that the Lyman-Haskell accelerating or multicharge gun, recently cast at Reading, Pa., be transported to Sandy Hook, and thoroughly tested under the direction of the War Department, at the expense of the United States, as proposed by Mr. Haskell in his communication of October 5, 1881.

The Board then adjourned to meet the 23d instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, November 23, 1881.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 23d instant were then read.

Mr. Norman Wiard's plans, specifications, correspondence, &c., in relation to sea-coast fortifications and heavy guns (L. R. No. 103), were taken up, and, after careful consideration, were laid aside, to be acted upon at the next meeting of the Board.

The plans, specifications, estimates, &c., presented by Mr. H. F. Mann (L. R. No. 205), were then taken up, and, after careful consideration, were laid aside for future action.

The Board then adjourned to meet the 28th instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, November 28, 1881.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 23d instant were then read.

Mr. Norman Wiard's plans, specifications, correspondence, &c. (L. R. No. 103), were then taken up for final consideration, and, after discussion, the following resolution was unanimously adopted:

That, as the Board does not assent to the arguments of Mr. Norman Wiard, as set forth in the various letters, papers, &c., accompanying his proposals of July 1, 1880, and March 28, 1881, referred to it through the Chief of Ordnance by the Secretary of War, in indorsements on letter of Mr. Wiard of the 14th of May, 1881, to show the superiority and expediency of adopting his plans of gun conversion, it does not recommend the acceptance of the proposals.

The plans, specifications, estimates, &c., presented by Mr. H. F. Mann (L. R. No. 205) were then taken up, carefully considered and discussed, and laid aside for future action.

The Board then adjourned to meet at Sandy Hook, N. J., the 29th instant.

SANDY HOOK, N. J.,
November 29, 1881.

The Board met, pursuant to adjournment.

Present: All the members and the recorder.

The Board then examined the various pieces of ordnance at this place, after which it adjourned, to meet in New York City on the 30th instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, November 30, 1881.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 28th and 29th instants were then read.

The plans, specifications, estimates, &c., presented by Mr. H. F. Mann (L. R. No. 205) were taken up and fully discussed, final action thereon being deferred.

The plan of gun construction, projectile, fuse, and carriage, submitted by Master Samuel Seabury, U. S. N. (L. R. Nos. 110 and 121), and the plans of gun construction and projectile submitted by Paulding, Kemble & Co., of Cold Spring, N. Y. (L. R. No. 194), were considered, but, without action, the Board adjourned, to meet the 1st proximo, at 11 o'clock a. m.

ARMY BUILDING,
New York City, December 1, 1881.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 30th ultimo were then read.

The plans of gun construction, projectile, fuse, and carriage submitted by Master Samuel Seabury, U. S. N. (L. R. Nos. 110 and 121), were taken up for final action, and the following resolution unanimously adopted:

That the gun construction for a 9-inch gun, submitted by Master Samuel Seabury, U. S. N., is objectionable in several respects, principally in the fact that a large mass of steel is required for the breech receiver, which would be difficult to make and difficult to work sufficiently, particularly in this country, to insure that homogeneity necessary for strength in that part of the construction in connection with his special fermeture; again, the breech receiver projects unsupported beyond the body of the gun, and is thus subjected to vibrations; again, the breech mechanism is similar, but not superior, to the Krupp, which this Board is not prepared to recommend. For these reasons it is not recommended for actual test. The Board is of the opinion that the particular merit or advantage claimed by Master Seabury for his projectile is only a matter which can be definitely determined by actual experiment, which the Board is not in a position to undertake. And while the results in Europe of the use of copper bands are sufficiently satisfactory, the details of the number of bands, their size, and the mode of attachment, as they affect the strength and ability to penetrate iron armor, should, in the opinion of the Board, be left to future experiment. And it is therefore recommended that this projectile be tried by the Ordnance Department, with others, when circumstances and opportunity are favorable.

The subject of gun carriages and fuses is not within the scope of the Board's investigations.

The plans of gun construction, including that of the proposed 12-inch B. L. rifles, submitted by Col. S. Crispin, Ordnance Department (L. R. No. 144), and by Capt. C. S. Smith, Ordnance Department (L. R. No. 67), were taken up, carefully considered, and laid aside for future action.

The plans of gun construction and projectile submitted by Paulding, Kemble & Co., of Cold Spring, N. Y. (L. R. No. 194), were taken up, carefully considered, and laid aside temporarily, to allow Mr. A. H. Emery, of New York, to present his systems of gun construction to the Board.

Paulding, Kemble & Co.'s plans were then further discussed, and the following resolution unanimously adopted:

That Messrs. Paulding, Kemble & Co.'s gun construction, as explained in their printed letter and accompanying drawing, No. 2, has merit in common with like combinations involving a cast-iron case jacketed and hooped with steel, but in the opinion of the Board the wrought-iron lining-tube is objectionable. The arrangement of the contiguous parts in connection with the screw-breech closure is a good one to secure strength against fracture by longitudinal strains. The characteristic feature of this gun construction, however, seems to be the casting of the iron case in two pieces, which will effect a great saving, provided it prove efficient in strength. If any guns are made after this general system of metal combination it is recommended that the case of one be cast in two pieces for trial to test its strength. Their proposed method of improvement upon the system of construction presented by Colonel Crispin, Ordnance Department, exhibited in drawing No. 1, simply involves the same method of casting the case, and is therefore disposed of by the above action of the Board.

The Board then adjourned, to meet the 2d instant, at 11 o'clock a. m.

ARMY BUILDING,
New York City, December 2, 1881.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 1st instant were then read.

The plans of gun construction, including that of the 12-inch B. L.

rifles, submitted by Col. S. Crispin, Ordnance Department (L. R. No. 144), and by Capt. C. S. Smith, Ordnance Department (L. R. No. 67), were taken up, carefully considered and discussed, and laid aside, to be acted upon at the next meeting of the Board.

The plans of gun construction submitted by Mr. A. H. Emery were then taken up, carefully considered and discussed, but, without action, the Board adjourned, to meet the 5th instant, at 11 o'clock a. m.

ARMY BUILDING,
New York City, December 5, 1881.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 2d instant were then read.

A letter from Mr. D. M. Mefford, of Toledo, Ohio (L. R. No. 207), stating that he would appear before the Board about December 10, was read, and the recorder directed to request Mr. Mefford to delay his visit until the 18th of January. (Letter-book 196.)

A letter from Mr. J. R. Haskell (L. R. No. 209), stating that he would forward, as soon as completed, the estimates asked for in the Board letter of the 28th ultimo, was read and filed.

A letter from the Ordnance Board to the Chief of Ordnance, referred to this Board by that officer, together with his letter to the Ordnance Board, dated November 16, 1881 (L. R. No. 210), was read and filed.

A letter from Dr. J. H. McLean, of Saint Louis, Mo. (L. R. No. 208), again calling attention to his inventions, was read, and the recorder directed to request Dr. McLean to send his drawings and estimates to this office by the 10th of next month, that they may be examined. (Letter-book No. 197.)

Respecting the plans of gun construction submitted by Col. S. Crispin and Capt. C. S. Smith through the Chief of Ordnance, viz:

Two cast-iron casings with steel tube and breech receiver—one having an interrupted screw fermeture, the other a round wedge fermeture;

Three cast-iron casings with steel breech receiver—two with interrupted screw, and one with round wedge fermeture; and

Four cast-iron casings with wrought iron tube and steel breech receiver—three with interrupted screw and one with round wedge fermeture.

Those having combinations of wrought iron—particularly coiled wrought iron—as a lining for steel breeching and cast-iron casing are, in the Board's estimation, objectionable. Although the greater part of the conversions using wrought iron as a lining tube, as detailed in the yearly reports of the Chief of Ordnance, have given in small guns apparently good and encouraging results, it is on the whole, considering the history of all the guns so converted and constructed, including the 11-inch and 12.25 inch, a questionable success. But in so expressing itself the Board desires it to be distinctly understood that it does not overlook the fact that in the small guns referred to comparatively ineffective smooth bores have been converted into effective rifles; deeming it simply unwise to continue the use of wrought iron tubes, particularly for B. L. conversions, and all calibers above 8-inch, until it shall have been shown that other conversions and constructions are not what, from the most advanced views, we have a right to expect.

Of those with steel breech receivers, with and without steel tubes, those having the round wedge fermeture require a breech receiver so massive that the necessary working of the metal, to give it the uniform strength required for such construction, is impracticable in this country at this time; it being the opinion of the Board that this system of fermeture requires, to compensate for the cutting away of so much metal, a highly wrought steel of homogeneous structure, the difficulties of producing which increase very rapidly with the size of the piece; and those with the interrupted screw fermeture, the breech receiver extending beyond the casing, lack its support, and may for that reason be defective in strength, and require, like those with the wedge fermeture, a highly wrought and large piece of steel.

The plans of gun construction, including that of the 12-inch B. L. rifles, submitted by Col. S. Crispin, Ordnance Department (L. R. No. 144), and by Capt. C. S. Smith, Ordnance Department (L. R. No. 67), were taken up for final action; and, after consideration and discussion, the following resolution unanimously adopted:

Resolved, In view of the objections above set forth, that this Board does not recommend any of these constructions for trial.

Dr. W. E. Woodbridge then addressed the Board in reference to the cutting up of his gun, to obtain specimens for test, and presented the estimate of the Delamater Iron Company for doing the work required. (L. R. No. 211.)

The matter was discussed at length, and laid aside for future action.

Mr. A. H. Emery then presented the completed drawings, estimates, &c., ordered from him.

The Board then adjourned to meet the 6th instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, December 6, 1881.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 5th instant were then read.

The question of cutting up the Woodbridge gun was discussed at length, and the following resolution unanimously adopted:

Resolved, That the two parts of the gun be cut up as proposed by Dr. Woodbridge, in order to reveal its interior condition, and to subject it to such tests as will furnish information needed by the Board to come to a more definite opinion as to its merits and demerits.

As the wire-wrapped and brazed 10-inch gun, constructed by the government under the direction of Dr. Woodbridge, the proposer of the system, and subjected to test by this Board until after a total of ninety-three rounds, the last under the high pressure of 74,400 pounds per square inch, it was broken crosswise where it had revealed a weakness at the third round, showed a tenacity favorable to that system of structure, provided the manipulation could be made perfect; in view of the expense already incurred in making the gun, and its exhibited tenacity, and the desire to learn in what way the method of fabricating it has failed to produce a perfect brazing;

The following resolution was unanimously adopted:

That a committee of the Board, to consist of Col. Z. B. Tower, Lieut. Col. A. R. Buffington, Maj. F. H. Parker, Maj. J. Mendenhall, and the recorder, meet at the South Boston Iron Company's Works, Boston, Mass., Wednesday, December 14, 1881, at 11 o'clock a. m., to make an examination of the plant and material at that place, and also visit Watertown Arsenal, Mass., to examine the United States Testing Machine.

There being no business before the Board upon which it could act immediately, and to allow time for further information to be procured and certain preliminary steps to be taken, the Board then adjourned to meet the 18th of January, 1882, at 11 o'clock a. m.

BOSTON, MASS., *December* 14, 1881.

The committee of the Board met, pursuant to resolution.

Present: Colonel Tower, Lieutenant-Colonel Buffington, Major Parker, Major Mendenhall, and the recorder.

The committee then proceeded to examine the plant and material at the South Boston Iron Company's Works, including the steel breech-receivers intended for the four 12-inch B. L. rifles contracted for by the Ordnance Department, and the preparations made for casting and finishing those guns.

Dr. McLean then explained his system of gun construction, and his model and drawings were examined.

The committee then proceeded to Watertown Arsenal, Massachusetts, and examined the United States Testing Machine at that place, after which it adjourned to meet in New York City on January 18, 1882, the day for the reassembling of the full Board.

ARMY BUILDING,
New York City, January 18, 1882.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of December 6 were then read.

The Board then proceeded to the consideration of the matter presented to it in its correspondence, viz:

A letter from Mr. E. Drew, of Boston, Mass. (L. R. No. 222), asking for certain information in regard to the 80-ton English gun, and whether any improvement in the metal used in casting heavy cannon which he might invent would be profitable to him.

The recorder was directed to inform Mr. Drew that the Board was convened to examine models, plans, &c., of gun construction that might be presented to it, and can give no opinions upon the matter referred to in his letter. (Letter-book No. 209.)

A letter from Mr. J. Reese, of Pittsburgh, Pa. (L. R. No. 221), asking to be informed of the action of the Board in his case.

The recorder was directed to inform Mr. Reese that the opinions of the Board can only be made known through the War Department after its report has been made to the Secretary of War for transmission to Congress. (Letter-book No. 208.)

A letter from Mr. F. M. Shields, of Coopwood, Miss. (L. R. No. 220), asking that his papers be returned (the papers referred to are L. R. No. 169, acted on at the meeting of the Board October 20, 1881—see page 177 of proceedings and Letter-book No. 176.)

The recorder was directed to return the papers as requested. (Letter-book No. 211.)

A letter of Mr. F. M. Shields, of Coopwood, Miss., referred to the Board by the Chief of Ordnance (L. R. No. 224), saying that he had heard nothing from the specifications, &c., of his "multi-gun" forwarded to the Board.

The letter was returned to the Chief of Ordnance with the remark that no project such as described in the letter has been received. (Letter-book No. 210.)

A letter from Mr. W. P. Hunt, of Boston, Mass. (L. R. No. 213), submitting estimates of the cost of the items enumerated in the Board letter of November 28, 1881, was read and filed.

A letter from Mr. D. M. Mefford, of Toledo, Ohio (L. R. No. 219), stating that he intended to have a working model of his gun made to submit with his drawings, was read—had been answered by the recorder during recess of the Board to the effect that the drawings only were desired.

The answer was approved.

Letters from the Chief of Ordnance (L. R. No. 214) authorizing the Board to have the Woodbridge gun cut up, and from Lieut. Col. T. G. Baylor, Ordnance Department (L. R. No. 218), stating that the Woodbridge gun had been shipped to the Delamater Iron Company, were read and filed.

A letter from Dr. J. H. McLean, of Saint Louis, Mo. (L. R. No. 223), transmitting model, drawings, and description of his "Hercules" gun, was read and laid aside for future action.

A letter from Knight Bros., Washington, D. C. (L. R. No. 225), asking whether Dr. McLean's model was received in time and safely, was read—had been answered in the affirmative. (Letter-book No. 207.)

The model and photographs of a spiral projectile submitted by Mr. D. L. Kennedy, of New York, were laid aside for future consideration.

The plans and specifications of breech mechanism, projectile, &c., submitted by Chief Engineer George Quick, R. N., Hidcote House, Chipping Campden, England (L. R. No. 215), were laid aside for future consideration.

The agreement of Delamater & Co. to prepare specimens from the Woodbridge wire gun (L. R. No. 212) was read and laid aside for future consideration. A letter from the Chief of Ordnance (L. R. No. 216), forwarding report of the firing in the proof of 8-inch breech-loading rifle, No. 5, and the opinion of experts on the quality of the metal in the breech receiver, with records of tests of metal, &c., was read, and the matter laid aside for future consideration.

Mr. H. F. Mann, of Pittsburgh, Pa., then addressed the Board in reference to his inventions, after which the Board resumed the consideration of the matter presented to it in its correspondence, viz:

A letter from the Chief of Ordnance (L. R. No. 226), transmitting plans of a 12-inch B. L. rifle on the French and Italian systems of construction, with letter of explanation, blue prints, and remarks thereon, together with a report on the steel manufacturing facilities of the country—laid aside for future consideration.

The Board then discussed generally, at some length, a plan of work, and afterwards the drawings, model, &c., of Dr. McLean's "Hercules" gun, but, without action, adjourned, to meet the 19th instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, January 19, 1882.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 14th ultimo and of the 18th instant were read.

Mr. A. H. Emery, of New York, then again addressed the Board in reference to his systems of gun construction.

The model, plans, and description of the system of gun construction, and plans and descriptions of projectiles presented by Dr. J. H. McLean of Saint Louis, Mo. (L. R. No. 223), were then taken up for final action, and, after consideration and discussion, the following resolution was unanimously adopted:

That the Board regards the system of gun construction presented by Dr. J. H. McLean, of Saint Louis, Mo., as exhibited in his plans and description, as defective in the following respects: That the weight of the whole gun and its parts is objectionable; that it has a multiplicity of parts and much complex machinery; that the breech block is much larger and heavier than those successfully and extensively now in use; that the system is deficient in strength, and upon the whole is impracticable for heavy ordnance. And the Board does not recommend it therefore for actual test. A careful examination of the plans and descriptions of projectiles submitted by Dr. McLean does not show that any of them has sufficient merit to warrant a recommendation for trial.

The plans and description of breech mechanism for ordnance, and the plans of a projectile submitted by Chief Engineer George Quick, R. N., Hidcote House, Chipping Campden, England, (L. R. No. 215), were taken up for consideration, and after examination and discussion laid aside for further action.

The letter from the Chief of Ordnance (L. R. No. 226), transmitting plans and descriptions of the French and Italian systems of gun construction, with accompanying papers, was taken up for consideration, the letter and accompanying papers read, and the Board then adjourned, to meet the 20th instant, at 11 o'clock a. m.

ARMY BUILDING,
New York City, January 20, 1882.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 19th instant were read.

A letter from the Chief of Ordnance to the Secretary of War, inclosing a communication from Mr. W. P. Hunt, president of the South Boston Iron Company, requesting assistance in his efforts to obtain government aid to construct a complete ordnance manufactory, referred to the Board by the Secretary of War for an expression of its opinion upon the subject (L. R. No. 227), was read, together with the inclosure. The matter was discussed at length and finally laid aside for future action.

The letter from the Chief of Ordnance (L. R. No. 226), transmitting plans and descriptions of the French and Italian systems of gun construction, was taken up and considered at length: but, without action, the Board adjourned, to meet the 23d instant, at 11 o'clock a. m.

ARMY BUILDING,
New York City, January 23, 1882.

The Board met, pursuant to adjournment, at 11.10 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 20th instant were read.

A letter from Paulding, Kemble & Co., proprietors of the West Point Foundry, Cold Spring, N. Y. (L. R. No. 229), to the Chief of Ordnance, submitted by him to the Secretary of War, and referred by the latter to the Board in connection with the paper of Mr. W. P. Hunt, and remarks of the Chief of Ordnance thereon (L. R. No. 227), was read.

Paulding, Kemble & Co. state that they have seen Mr. Hunt's letter; that they agree with him in his statements, and think that the method he proposes, *i. e.*, of the government extending aid to private manufactories, is the only way to establish the necessary "plant" for the manufacture of heavy guns of recent design.

A letter from Mr. Timothy Davis, of Washington, D. C., to the President of the Board (L. R. No. 228), stating as their representative that there is a perfect understanding between the managers of the South Boston Iron Company and the West Point Foundry, and that they will both appear before the Board if desired, was read.

These letters were then considered in connection with Mr. Hunt's communication and the remarks of the Chief of Ordnance and the opinion of the Board prepared. (Letter-book, pages 212–13–14–15–16.)

The letter from the Chief of Ordnance (L. R. No. 226), transmitting plans and descriptions of the French and Italian systems of gun construction, was taken up and considered at length, but, without action, the Board adjourned, to meet the 24th instant, at 11 o'clock a. m.

ARMY BUILDING,
New York City, January 24, 1882.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 23d instant were read.

The Board then proceeded to the consideration of a letter from the Chief of Ordnance (L. R. No. 231), transmitting reports of the Ordnance Board on the bursting of 8-inch and 11-inch B. L. chambered rifles, with his remarks thereon, and appendices giving valuable information relative to heavy guns, the experiments and conclusions of eminent ordnance authorities, and records of the endurance of tubed cast-iron guns.

The letter and a number of the appendices were read, and the matter laid aside for further action.

The letter from the Chief of Ordnance (L. R. No. 226), transmitting plans and descriptions of the French and Italian systems of gun construction, was taken up and considered at length, but, without action, the Board adjourned, to meet the 25th instant, at 11 o'clock a. m.

ARMY BUILDING,
New York City, January 25, 1882.

The Board met, pursuant to adjournment, at 11.20 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 24th instant were read.

A letter from Mr. D. M. Mefford, of Toledo, Ohio (L. R. No. 232), giving a description of his method of constructing heavy ordnance and inclosing plans, was read, and after careful examination of the plans and description the following resolution was unanimously adopted:

That the Board does not approve of the plans of gun construction submitted by Mr. D. M. Mefford, of Toledo, Ohio, and cannot, therefore, recommend a gun constructed on such a plan for actual test.

Mr. Mefford so informed, by direction of the Board. (Letter-book No. 217.)

The letter from the Chief of Ordnance (L. R. No. 226) transmitting plans and descriptions of the French and Italian systems of gun construction was taken up, considered at length, and laid aside for future action.

The plans of gun construction presented by Mr. A. H. Emery, of New York (L. R. No. 230), were then considered and discussed at length, and laid aside for further action.

The plans and description of breech mechanism for ordnance and the plans of a projectile submitted by Chief Engineer George Quick, R. N., Hidcote House, Chipping Campden, England (L. R. No. 215), were then taken up for final action, carefully considered, and the following resolution unanimously adopted:

That the breech-loading device of Chief Engineer George Quick, R. N., though of doubtful superiority to other systems now extensively used abroad, yet appears to possess sufficient merit to warrant its trial should the Ordnance Department find it convenient so to do in the construction and test of new cannon.

The Board then adjourned, to meet the 26th instant, at 11 o'clock a. m.

ARMY BUILDING,
New York City, January 26, 1882.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: General Getty, Colonel Tower, Major Parker, Major Mendenhall, and the recorder.

Absent: Lieutenant-Colonel Buffington; by permission of the Board.

The proceedings of the 25th instant were read and discussed.

After an extended discussion of the plans before it and of gun construction generally, the Board adjourned, to meet the 30th instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, January 30, 1882.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 20th instant were read.

A letter from the Chief of Ordnance (L. R. No. 233), transmitting, for the information of the Board, certain extracts from foreign publications relative to steel-wire guns, and setting forth the advantages of using built-up guns, in contradistinction to homogeneous or simple cast guns, as a means of securing the greatest strength and least weight in gun construction, was read, together with the inclosures, and filed for reference.

A letter from Capt. J. G. Butler, Ordnance Department (L. R. No. 234), submitting drawings of three systems of gun construction, urging their trial and giving his reasons therefor, was read, and laid aside for future consideration.

Dr. W. E. Woodbridge then read to the Board a paper (L. R. No. 235) describing in detail the method of brazing his wire gun, explaining the cause of the imperfect brazing in the ruptured gun, and the remedy for that defect in future construction. Dr. Woodbridge afterwards addressed the Board in reference to his system of construction generally.

The Board then adjourned, to meet the 31st instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, January 31, 1882.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 30th instant were read.

Some points in regard to the tests to be made of the specimens from the Woodbridge gun were referred to and discussed with Dr. Woodbridge, after which the Board commenced the revision of the record of its proceedings.

The Board then adjourned, to meet the 1st proximo at 11 o'clock a. m.

ARMY BUILDING,
New York City, February 1, 1882.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: General Getty, Colonel Tower, Lieutenant-Colonel Buffington, Major Mendenhall, and the recorder.

Absent: Major Parker; by authority of the Board.

The proceedings of the 31st ultimo were read.

The Board concluded the revision of the record of its proceedings.

The letter of Mr. C. B. Barrows, of Brooklyn, N. Y. (L. R. No. 236), calling attention to the application of a new principle to the science of gunnery, transmitted to the Board by the Chief of Ordnance, was read, and the Board then adjourned, to meet the 3d instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, February 3, 1882.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 1st instant were read.

The consideration of Mr. C. B. Barrow's letter (L. R. No. 236) was continued, and the following resolution unanimously adopted:

That the Board regards Mr. C. B. Barrow's device for exhausting the air from guns before firing them as impracticable.

A copy of the correspondence in connection with the Board letter of October 26, 1881, asking for information in regard to the construction, &c., of Italian heavy ordnance, transmitted to the Board by the Adjutant-General of the Army (L. R. No. 238), was read and filed.

A letter from the Chief of Ordnance (L. R. No. 239), transmitting paper translated from the Revue d'Artillerie, relative to the construction and trial of the Italian 100-ton rifled gun, was read, together with the translation, and laid aside for future consideration.

The Board then discussed at length the various plans of gun construction before it. There being no further business before it upon which immediate action could be taken, the Board then adjourned, to meet the 1st of March at 11 o'clock a. m., or sooner, at the call of the President, if necessary, for the transaction of business.

ARMY BUILDING,
New York City, March 1, 1882.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 2d ultimo were read.

The Board then proceeded to the consideration of the new matter presented in correspondence, viz:

A letter from the Hon. H. L. Dawes to the Secretary of War, and referred by the latter to the Board for the information desired.

The letter was read, together with the indorsement of the President of the Board, and filed (L. R. No. 241).

A copy of the correspondence in connection with the Board letter of October 26, 1881, asking for information in regard to the method of constructing the most recent French cannon, including the Schultz wire gun, transmitted to the Board by the Adjutant-General of the Army (L. R. No. 241), was read and filed.

The modified proposal of Mr. Norman Wiard to the Secretary of War (L. R. No. 242), transmitted by the latter to the Board for consideration in connection with the previous proposal bearing date March 28, 1881, was read and laid aside for future action.

A letter from Mr. C. A. Hotchkiss, of Bridgeport, Conn. (L. R. No. 243), submitting drawing and description of Mr. B. B. Hotchkiss's projectile for breech-loading ordnance, was read, the plan and sample projectile examined, and the matter laid aside for future action.

A letter from the Chief of Ordnance (L. R. No. 244), transmitting certain papers and drawings, studies on guns, left at the Ordnance Office by Mr. Paulding, of Cold Spring, N. Y., was read, together with the inclosures, and laid aside for future action.

A letter from the Chief of Ordnance (L. R. No. 245), transmitting a copy of a report made by Capt. J. G. Butler on the trial, by means of gunpowder, of cast-iron cylinders, lined and unlined, was read, and filed for reference.

A letter from the Chief of Ordnance (L. R. No. 247), transmitting a copy of Col. T. T. S. Laidley's report on the trial of two cast-iron guns, one lined with wrought-iron tube, and making certain remarks thereon, was read, together with the inclosures, and filed for reference.

A letter from Capt. C. S. Smith, Ordnance Department, transmitted to the Board by the Chief of Ordnance (L. R. No. 248), giving in connection with his letter of December 30, 1881, certain information as to the method used in assembling the parts of the French cast-iron and steel guns, and also the translation of an extract from the *Revue d'Artillerie* giving the latest information in regard to the Italian 100-ton gun, was read, together with the inclosures, and filed for reference.

The Board then adjourned, to meet the 2d instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, March 2, 1882.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 1st instant were read.

The following letters and accompanying papers, which had been laid aside for further consideration, were then directed to be filed for reference, viz:

Letters received, Nos. 150, 216, 231, 233, and 239, from the Chief of Ordnance.

Letter received, No. 234, from Capt. J. G. Butler, Ordnance Department, was directed to be filed, as the subject had been acted upon.

The letter from the Chief of Ordnance (L. R. No. 244), transmitting certain papers, drawings, &c., for Paulding, Kemble & Co., was then taken up, the drawings carefully considered and examined, and the following resolution unanimously adopted:

That the breech-loading device presented by Paulding, Kemble & Co., shown in drawing marked "Study in Ordnance," submitted by the Chief of Ordnance with his letter dated February 6, 1882, appears to possess sufficient merit to warrant its trial, should the War Department find it proper so to do, in the construction and test of new cannon.

The modified proposal of Mr. Norman Wiard (L. R. No. 242), transmitted to the Board by the Secretary of War, was then taken up for final action, and after careful consideration and discussion the following resolution was unanimously adopted:

With regard to Mr. Norman Wiard's modifications of his proposals of the 28th of March, 1881, presented to the Board by indorsement of the Secretary of War dated February 3, 1882, viz, dividing said proposal of March 28, 1881, into four parts, for the purpose—

1st. Of furnishing part of the powder for the tests and determining the best kind to be used for the guns referred to; the best width and depths of grooves and pitch of rifling for these guns, with original length of bores unchanged; to testing the power of these guns for penetration into iron and earth, when converted into combined rifles and smoothbores; to apply and test the "snubbing-rope" plan for checking recoil; to take velocities of all projectiles during this part of experiments, &c.

2d. To test by rapid firing the endurance of the guns referred to above.

3d. To confine experiments "to the conversion, trial, and proof of powder for the penetration of iron targets and earth works of two 15-inch smooth-bore Rodman guns into long-bore breech-loading rifled guns," &c.

4th. The furnishing of all supplies as stated in detail.

Resolved, Inasmuch as the Board does not approve of the conversion of any of the smooth-bore guns now possessed by the government, and particularly does not approve of the system or systems proposed by Mr. Wiard, that said amended proposals be not recommended for acceptance by the War Department, and (referring to the Secretary of War's indorsement) that the Board does not consider the form of the proposals objectionable, and therefore has no modifications to suggest.

The model and photographs of Mr. D. L. Kennedy's "spiral drill-pointed projectile" (L. R. No. 127) was then taken up for final action, and the following resolution unanimously adopted:

That if at any time the Ordnance Department should be engaged in experiments to determine the penetration of different kinds of projectiles into iron, this Board recommends that Mr. Kennedy's proposed spiral projectile be also tried, but it is not deemed advisable to construct an iron target simply to test his device.

The letter of Mr. C. A. Hotchkiss (L. R. No. 243), transmitting tracing and sample of Mr. B. B. Hotchkiss's projectile for breech-loading guns, was then taken up for final action, and the following resolution unanimously adopted.

That, with regard to the Hotchkiss projectile, submitted with letter of February 6, inclosing a tracing of it, as it is known by actual test to be a good and reliable projectile for B. L. guns, resolved that it be recommended for further trial by the Ordnance Department.

The drawing of the improved Parrott projectile, submitted by Paulding, Kemble & Co. (L. R. No. 194), was then examined, and the following resolution unanimously adopted.

That the improved Parrott projectile for muzzle-loading guns is recommended for actual test in connection with other projectiles in experimental or practice firing with the 8-inch muzzle-loading rifle.

The Board then adjourned, to meet the 3d instant at the Delamater Iron Works at 11 o'clock a. m.

DELAMATER IRON WORKS,
New York City, March 3, 1882.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The Board then examined the parts of the Woodbridge 10-inch M. L. rifled wire gun, and afterwards proceeded to the Army Building, where the proceedings of the 2d instant were read.

The Board then adjourned, to meet the 6th instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, March 6, 1882.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 3d instant were read.

Mr. A. H. Emery, of New York, presented to the Board several plans for gun conversion (L. R. No. 249), and the detailed estimate of the cost of the sections and models made after the drawings prepared by him for the Board (L. R. No. 250.)

The Board discussed at length several of the plans before it, and then adjourned, to meet the 7th instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, March 7, 1882.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 6th instant were read.

A letter from Mr. J. R. Haskell, of New York City (L. R. No. 251), submitting, as requested by the Board in letter of November 28, 1881, an estimate of the cost of firing the "Lyman-Haskell multi-charge gun" 100 rounds, was read, discussed, and filed for reference.

The plans of gun construction and conversion submitted by Mr. A. H. Emery, of New York (L. R. Nos. 230 and 249), were examined and discussed, the accompanying descriptions and estimates read, and the matter laid aside for future action. The estimates of the weights and cost of the several sections and models of systems of gun construction to be made after the drawings prepared for the Board by Mr. A. H. Emery (L. R. No. 250) were read, and the subject discussed at length.

The Board then adjourned, to meet the 8th instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, March 8, 1882.

The Board met, pursuant to adjournment, at 1 o'clock p. m.

Present: All the members and the recorder.

The proceedings of the 7th instant were read.

Mr. J. R. Haskell, of New York City, then addressed the Board in reference to the "Lyman-Haskell multi-charge gun," and asked that the Board recommend the trial of the gun in process of manufacture at Reading, Pa.

Dr. W. E. Woodbridge then addressed the Board in reference to his wire gun.

The Board then adjourned, to meet the 9th instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, March 9, 1882.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: General Getty, Colonel Tower, Major Mendenhall, and the recorder.

Absent: Lieutenant-Colonel Buffington and Major Parker; by permission of the Board.

The proceedings of the 8th instant were read.

Dr. W. E. Woodbridge addressed the Board in regard to the tests to be made of specimens taken from his wire gun.

Mr. A. H. Emery then addressed the Board at length in regard to his systems of gun construction and conversion.

Mr. W. P. Hunt, President of the South Boston Iron Company, then submitted to the Board drawings of all steel, steel and cast-iron, and steel and bronze guns, and briefly explained them, stating that he intended to submit a written description and estimate of the cost of the several constructions at an early date.

The Board then adjourned, to meet the 10th instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, March 10, 1882.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: General Getty, Colonel Tower, Major Mendenhall, and the recorder.

Absent: Lieutenant-Colonel Buffington and Major Parker; by permission of the Board.

The proceedings of the 9th instant were read.

The Board discussed, generally, the matter before it, and then adjourned, to meet the 13th instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, March 13, 1882.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: General Getty, Colonel Tower, Major Parker, Major Mendenhall, and the recorder.

Absent: Lieutenant-Colonel Buffington; by permission of the Board.

The proceedings of the 10th instant were read.

A telegram from Lieutenant-Colonel Buffington (L. R. No. 252), giving the reason for his absence, was read.

A letter was addressed to Col. T. T. S. Laidley, commanding Watertown Arsenal, in reference to the tests to be made of specimens taken from the Woodbridge gun. (Letter-book No. 220.)

The recorder was directed to proceed to Boston to superintend the preparation and test of the specimens at Watertown Arsenal. (Letter-book No. 223.)

The Board then adjourned to meet the 30th instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, March 30, 1882.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 13th instant were read.

A letter from F. M. Shields, of Coopwood, Miss. (L. R. No. 255), making inquiries for his "multi-gun" which he claims to have sent to the Board, was read, and the recorder directed to reply, giving Mr. Shields all the information possible in regard to his inventions which have been received and examined. (Letter-book No. 226.)

Mr. H. F. Mann, of Pittsburg, Pa., then addressed the Board in reference to his system of gun construction, and submitted a paper (L. R. No. 258) in continuation of and in addition to his previous communications.

Mr. Henry Durell then addressed the Board in reference to a system of gun construction, explaining generally the manner of construction by a model. After discussion, Mr. Durell withdrew, with the understanding that he could submit a definite plan to the Board at a later day if he desired.

Ordnance note No. 174, relating to the Italian 100-ton gun, received from the Chief of Ordnance (L. R. No. 257), was filed for reference.

A letter from the Chief of Ordnance (L. R. No. 256), transmitting the first chapter of Colonel Crispin's report on European heavy ordnance, with remarks thereon, was read. The reading of the report was commenced, but before conclusion the Board adjourned, to meet the 31st instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, March 31, 1882.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 30th instant were read.

The results of the tests made at Watertown Arsenal of specimens from the Woodbridge gun were explained to the Board.

The report is hereto appended, marked "B."

The reading of the report on heavy ordnance of England, by Col. S. Crispin, Ordnance Department, transmitted to the Board by the Chief of Ordnance (L. R. No. 256), was concluded, and the Board then adjourned, to meet the 3d proximo at 11 o'clock a m.

ARMY BUILDING,
New York City, *April* 3, 1882.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 31st ultimo were read.

A letter from the Chief of Ordnance (L. R. No. 260), transmitting a copy of a letter from Mr. B. B. Hotchkiss, of Paris, France, descriptive of his wire gun, was read. Mr. Hotchkiss's letter and description were read, the drawing examined, and the matter laid aside for further consideration.

A letter from Capt. C. S. Smith, forwarding to the Chief of Ordnance plans of gun construction, additional to those previously forwarded, regarding a modification of the existing plans for the 12-inch B. L. rifles now under contract, referred by the Chief of Ordnance to the Board (L. R. No. 262), was read, the drawings examined and discussed, and the matter laid aside for further consideration.

A letter from Mr. W. P. Hunt, President of the South Boston Iron Company (L. R. No. 261), submitting a portfolio of drawings of projectiles of the kind which have been furnished to the government, with statement of their advantages over other kinds, was read, the drawings examined, and the matter laid aside for further consideration.

A letter from Mr. Hunt (L. R. No. 254), giving description, estimate of cost of construction, and proof of the all steel, steel and cast-iron, and steel and bronze guns, of which drawings were submitted on March 9, was read, the drawings examined, and the matter laid aside for further consideration.

The Board then adjourned, to meet the 4th instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, *April* 4, 1882.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 3d instant were read.

Mr. W. P. Hunt, President of the South Boston Iron Company, addressed the Board in reference to the drawings of projectiles submitted by him.

The Board then discussed several of the plans before it.

After some further discussion of various matters before it, the Board adjourned, to meet the 5th instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, *April* 5, 1882.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 4th instant were read.

The drawings of systems of gun construction ordered by the Board from Mr. A. H. Emery, and the estimate of the weight and cost of the different models and sections constructed after the drawings, with a view to comparative tests in the machine and with powder (L. R. No. 250), were taken up for final action, the drawings examined, the estimates read and discussed, and the following resolution unanimously adopted:

In the opinion of this Board much valuable knowledge would be gained for ordnance constructors and for the general ends of science, as to the relative effects of impulsive and continued forces, by a series of experiments of the nature set forth in this paper; yet, in view of the great cost (over $400,000), and of the delays that would be involved in carrying them out, they cannot be undertaken by this Board. It is, however, suggested that a limited number of trials be made in this direction with such models as will best tend to elucidate the subject.

The drawings and description of the Butler projectile, submitted by Mr. W. P. Hunt, President of the South Boston Iron Company (L. R. No. 261), were then taken up for final action and the following resolution unanimously adopted:

As the Butler projectile, of which drawings and description are submitted by Mr. W. P. Hunt, is known by actual trial to be a good and reliable projectile for both muzzle and breech-loading guns, it is recommended for further trial in competition with other projectiles.

The plans submitted by Mr. A. H. Emery, of New York City, for the conversion of 10-inch and 15-inch smooth-bore guns, being a part of those submitted with L. R. No. 253, were then examined and discussed, and the following resolution unanimously adopted:

The Board is of the opinion that the 15-inch and 10-inch guns on hand are needed for service, as they are, and that it would be inexpedient to convert them into breech-loading rifles by any process. It cannot therefore recommend their conversion by the methods presented in Mr. Emery's plans.

The Board then adjourned, to meet the 6th instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, April 6, 1882.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 5th instant were read.

The Board discussed at length the Italian system of gun construction and examined the records of trials made with guns constructed on that plan.

A letter from Dr. W. E. Woodbridge (L. R. No. 263), giving the difficulties that may be found in accurately preparing and testing composite specimens, was read and filed.

The Board then adjourned, to meet the 7th instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, April 7, 1882.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: General Getty, Colonel Tower, Major Parker, Major Mendenhall, and the recorder.

Absent: Lieutenant-Colonel Buffington; by permission of the Board.

The proceedings of the 6th instant were read.

The plans of gun construction submitted by Mr. A. H. Emery (L. R. No. 253), and those submitted by Mr. W. P. Hunt (L. R. No. 254), were discussed, and the Board adjourned, to meet the 10th instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, April 10, 1882.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 7th instant were read.

The plans of gun construction and accompanying papers submitted by Mr. W. P. Hunt, president of the South Boston Iron Company (L. R. No. 254), those submitted by the Chief of Ordnance (L. R. No. 262), and those submitted by Mr. A. H. Emery (L. R. No. 253), were examined and discussed, and the Board then adjourned, to meet the 11th instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, April 11, 1882.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 10th instant were read.

A letter from Lieut. C. C. Morrison, Ordnance Department (L. R. No. 264), giving a description and inclosing drawing of a 12-inch steel "ribbon" gun, was read, the drawing examined, and the matter laid aside for future action.

The plans of gun construction submitted by Mr. W. P. Hunt, president of the South Boston Iron Company (L. R. No. 254), and those submitted by the Chief of Ordnance (L. R. Nos. 226 and 262), were examined and discussed, and the Board then adjourned, to meet the 12th instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, April 12, 1882.

The Board met, pursuant to adjournment, at 12 o'clock m.

Present: General Getty, Colonel Tower, Lieutenant-Colonel Buffington, Major Mendenhall, and the recorder.

Absent: Major Parker.

The proceedings of the 11th instant were read.

A telegram from Major Parker (L. R. No. 265), saying he could not attend the meeting of the Board, was read.

The Board discussed generally the subject of gun construction, and then adjourned, to meet the 13th instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, April 13, 1882.

The Board met, pursuant to adjournment, at 11.30 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 12th instant were read.

Several plans of gun construction not yet acted upon were discussed at length.

A design for an 8-inch steel wire B. L. gun, submitted by the Chief of Ordnance by indorsement on letter of Capt. C. S. Smith, was examined, the letters read, and the matter laid aside for further consideration. The Board then adjourned, to meet the 14th instant at 11 o'clock a. m.

Army Building,
New York City, April 14, 1882.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 13th instant were read.

The Board discussed at length several plans of gun construction before it.

There being nothing before it upon which immediate action could be taken, and to await the submission of further plans by several inventors, the Board then adjourned, to meet the 1st proximo at 11 o'clock a. m.

Army Building,
New York City, May 1, 1882.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 14th ultimo were read.

The letters from Lieut. C. C. Morrison, Ordnance Department, and Mr. W. P. Hunt (L. R. Nos. 268, 270, and 271), asking that they be allowed to make corrections of their drawinge, were read and filed. The requests had already been granted.

A letter was read from Capt. J. G. Butler, Ordnance Department (L. R. No. 272), asking that his communication to the Board on the subject of heavy ordnance be returned, as the same matter was before the Board from another source.

The recorder was directed to file the letter, and return the former communication as requested.

A letter from Col. T. T. S. Laidley, Ordnance Department (L. R. No. 273), submitting a plan and giving a description of the mode of constructing a cast-iron gun reinforced by wrapped wire, was read and laid aside for future consideration.

A letter from Mr. W. P. Hunt, President of the South Boston Iron Company (L. R. No. 274), submitting drawings and giving a description of guns of cast iron reinforced by steel wire, of cast iron reinforced by steel hoops, and of all steel, was read and laid aside for further consideration.

A letter from the Chief of Ordnance (L. R. No. 275), giving the record of firing with the 6-inch and 10.236-inch Armstrong steel riband guns, was read, together with the inclosures, and filed for reference.

A letter from the Chief of Ordnance (L. R. No. 276), submitting plans prepared by Capt. C. S. Smith, Ordnance Department, of a 12-inch M. L. rifled mortar, and alterations of plans previously submitted, as contemplated in letter of March 30, 1882, was read, and laid aside for further consideration.

A letter from Dr. W. E. Woodbridge to the Chief of Ordnance, referred to the Board by that officer (L. R. No. 278), submitting plans of heavy ordnance, with description and remarks, was read, together with the inclosures, and laid aside for further consideration.

The Board then proceeded to the consideration of the several plans of cast-iron hooped guns, being those submitted by Mr. W. P. Hunt (Design F_2), by the Chief of Ordnance (Plan $\frac{D}{1}$), and by Dr. E. W. Woodbridge (Drawing No. 1), but, without reaching a conclusion, adjourned, to meet the 2d instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, May 2, 1882.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 1st instant were read.

Mr. John J. Williamson then addressed the Board in regard to a steel and wrought-iron combination metal, the invention of Mr. Eldridge Wheeler, advocating the use of the metal in gun construction. Mr. Wheeler introduced Mr. Williamson to the Board by letter. (L. R. No. 277.)

Dr. W. E. Woodbridge then addressed the Board in reference to the plans submitted by him. (L. R. No. 278.)

The Board then examined the several plans of cast-iron guns banded, with and without tubes, and wire-wound, with and without tubes, but, without action, adjourned, to meet the 3d instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, May 3, 1882.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 2d instant were read.

Mr. H. F. Mann addressed the Board in reference to his system of gun construction.

Dr. W. E. Woodbridge addressed the Board in reference to the tests of specimens from his gun, and submitted a drawing showing the results of some tests made at the Washington navy-yard in 1879 (L. R. No. 282), and stated what he claimed as his own inventions in the drawings of guns and projectiles submittted to the Board.

The Board then examined and discussed the several plans of cast-iron guns banded, with and without tubes, and wire-wrapped, with and without tubes, but, without action, adjourned, to meet on the 4th instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, May 4, 1882.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 3d instant were read.

A letter from the Chief of Ordnance (L. R. No. 280), transmitting, for the information of the Board, a revised price-list of foreign ordnance, was read and filed for reference.

A letter from Dr. W. E. Woodbridge (L. R. No. 279), proposing a change in the length of his cast-iron wire-wound gun was read and laid aside for future action.

The Board then proceeded to the examination and discussion of the plans of cast-iron guns banded, with and without tubes, and wire-wound, with and without tubes, viz: Those submitted by Mr. W. P. Hunt, President of the South Boston Iron Company, Boston, Mass. (L. R. No. 269), marked Designs D, E, F, G, H, I, F_2, I_2, M, N; those submitted by the Chief of Ordnance (L. R. Nos. 226, 262, and 276), marked $\frac{A}{1}$, $\frac{A}{2}$, $\frac{A}{3}$, $\frac{B}{1}$, $\frac{B}{2}$, $\frac{C}{1}$, $\frac{C}{2}$, $\frac{D}{1}$, $\frac{D}{2}$, $\frac{E}{1}$, $\frac{E}{2}$, $\frac{F}{1}$, $\frac{F}{2}$, $\frac{G}{1}$, H, and K; that submitted by Col. T. T. S. Laidley, Ordnance Department (L. R. No. 273), marked

Figure 1, and those submitted by Dr. W. E. Woodbridge (L. R. No. 278), marked Plate I and II, and the following resolution was unanimously adopted:

The Board is of the opinion that the combined cast-iron and steel guns represented in the plans submitted by the Chief of Ordnance, with his letters of January 17 and April 29, 1882, marked M and H, and in the plan submitted by Dr. W. E. Woodbridge, with his letter of March 29, 1882, modified by letter of May 3, 1882, and marked Plate II, should be constructed and tried for the following reasons:

1st. Experience thus far gained with similar guns promises for the combination success within usual limits of powder pressure.

2d. They can be readily and rapidly produced in this country without incurring the delay of sending to foreign countries for large masses of forged steel.

The great weight of the foregoing guns recommended for test is, however, objectionable, and this Board would prefer such combinations of materials possessing the highest tensile strength as will produce with less weight a gun capable of giving the high velocities now sought for. But while this latter class of guns is being developed through a series of careful and costly experiments, some cheaper gun, though of less power, susceptible of rapid production in case of need, should be determined upon so that the country may not be left entirely defenseless.

The plan of a 12-inch M. L. rifled mortar, presented by the Chief of Ordnance (L. R. No. 276), and marked Plan L, was then examined, and the following resolution unanimously adopted:

The Board recommends that a rifled mortar be constructed for experiment, of the caliber and dimensions proposed by the Ordnance Department, with such projectiles as that department may determine as best suited for the purpose. These mortars are very much needed for harbor defense, and emplacements for them have already been made ready at many important places on our sea-coast.

The Board then examined and discussed the several plans of all-steel guns, but, without action, adjourned, to meet the 5th instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, May 5, 1882.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 4th instant were then read.

A telegram from the Hon. Secretary of War to the President of the Board (L. R. No. 283) asking that he be informed, if possible, when the report of the Board could be expected, was read, and by direction of the Board answered to the effect that the report might be expected on or before the 25th instant. (Letter-book No. 235.)

The Board then continued the examination and discussion of the plans of steel guns, viz. those submitted by Mr. W. P. Hunt, President of the South Boston Iron Company, Boston, Mass. (L. R. Nos. 254 and 269), marked Designs A, B, J, K, L, and B_2; those submitted by Mr. A. H. Emery, of New York (L. R. Nos. 230 and 253), marked Plates 1, 2, 3, 4, and 5, and that submitted by Dr. W. E. Woodbridge (L. R. No. 278), marked Plate III, and the following resolution was unanimously adopted:

This Board is of the opinion that an all-steel gun should be tested. Several of the plans for such guns presented to the Board—notably that submitted by Mr. W. P. Hunt, with his letter of April 15, 1882, marked Design B; that submitted by Mr. A. H. Emery, with his letter of January 23, 1882, marked Plate 5; and that submitted by Dr. W. E. Woodbridge, with his letter of March 29, 1882, marked Plate III—have undoubted merit. Of these we prefer the design of Mr. Hunt, but recommend for construction and trial a 10-inch gun, after the same plan, instead of the 8-inch gun shown on the drawing. Although aware that the construction of this gun is not at this time within the facilities afforded by our own manufactories, and will therefore involve the importation of the large steel tubes that go to make up the piece, we still think the gun should be tried to test the system as compared with other systems recommended, especially the forged steel and wire guns.

The Board then examined and discussed the several plans of steel-wire guns, but, without action, adjourned, to meet the 8th instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, May 8, 1882.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 5th instant were read.

The Board continued the examination and discussion of the plans of steel-wire guns, but final action thereon was deferred.

A letter from Maj. S. C. Lyford, Ordnance Department (L. R. No. 281), submitting plan and giving a description of the method of constructing a 12-inch wrought-iron gun, was read.

After careful examination and lengthy discussion the following resolution was unanimously adopted in reference thereto:

It is the opinion of the Board that the plan for a wrought-iron gun presented by Maj. S. C. Lyford, Ordnance Department, may be practicable for the lower caliber guns, but that it is of doubtful use for those of larger caliber, which, it is believed, can be better made of other material, and the gun is therefore not recommended for trial.

After some discussion the Board adjourned, to meet the 10th instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, May 10, 1882.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 8th instant were read.

A letter from Messrs. Eastland & Bonshire, of Sharpsburg, Pa. (L. R. No. 284), calling the attention of the Board to their glass "bomb shell," and requesting its examination, was read.

The recorder was directed to inform Messrs. Eastland & Bonshire that the subject of explosive shells is not deemed within the scope of the Board's investigations, which are confined strictly to inventions and improvements in heavy ordnance and projectiles. (Letter-book No. 236.)

A letter from Mr. W. T. Arrick, of Washington, D. C. (L. R. No. 285), submitting a "blue print" of the "Eureka" projectile, and requesting its careful consideration, was read and filed.

The subject had already been acted upon. (See page 180, proceedings of the Board.)

A copy of the letters patent in the case of Mr. Eldridge Wheeler's "improvement in working cast malleable metals" (L. R. No. 286) was received and filed.

The method of working had been personally explained to the Board by Mr. John J. Williamson. (See page 201, proceedings of the Board.)

A letter from Col. S. Crispin, Ordnance Department (L. R. No. 287), calling the attention of the Board to the two inclosed drawings, embodying Captain Schultz's plan for the division of strains in the construction of heavy cannon, which he deems worthy of consideration, and also referring to the system of obturation, the device of Colonel de Bange, now in use in the French land service, was read.

The Board then continued the examination and discussion of the plans of steel-wire guns, viz: Those submitted by Dr. W. E. Woodbridge (L. R. No. 278), marked Plate IV, V, VI, and VII; that submitted by the Chief of Ordnance (L. R. No. 276); that submitted by Mr. B. B. Hotchkiss, of Paris, France, through the Chief of Ordnance (L. R. No. 260); those submitted by Mr. W. P. Hunt, President of the South Boston Iron Company, Boston, Mass. (L. R. No. 269), marked Designs O and P; that submitted by Lieut. C. C. Morrison, Ordnance Department (L. R. No. 264); and that submitted by Col. S. Crispin, Ordnance Department (L. R. No. 287). With reference to the plans submitted by Dr. W. E. Woodbridge, marked Plates V and VI, the following resolution was proposed:

The plan of gun construction presented by Dr. W. E. Woodbridge, consisting of a steel tube wire wrapped and brazed, is not recommended for construction and test, because the construction of the 10-inch gun and the trials made subsequently of it do not give promise of its success in the construction of large guns.

The resolution was not adopted.

Noes—Major Mendenhall, Colonel Tower, and General Getty—3.

Ayes—Major Parker and Lieutenant-Colonel Buffington—2.

The following resolution was then proposed as a substitute and adopted:

A gun of 10-inch caliber, after the design of Dr. W. E. Woodbridge, was recommended for construction by the Board on Heavy Rifled Ordnance, convened by General Orders No. 57, of June 28, 1872. This device involved a steel tube to be bound around by steel wire under the requisite tension, and to be united by brazing with bronze. The gun was constructed at Frankford Arsenal, and submitted to the trial of ninety-three rounds, eighty-three of which were fired under the direction of this Board. It burst into two parts, just behind the trunnions, under a powder pressure of about 80,000 pounds to the square inch, as measured by the Rodman gauge. An examination and tests, at the Watertown Arsenal, of sections cut from the broken gun, revealed the fact that the brazing was imperfect. Several difficulties occurred in the construction of this piece from the lack of experience in applying the brazing system to so large a mass; and further it seems probable that undue initial strains were developed on the exterior in cooling, which assisted largely in producing the transverse rupture. Could the brazing have been moderately well effected and the interior and exterior coolings properly regulated, it is believed that the gun would have been exceptionally strong. It is a merit of this method of construction that the material is not liable to give way, causing rupture, without previous indications. The transverse crack behind the trunnions where the rupture took place increased during the firing by increments so minute that from the sixty-fifth to the eighty-fifth round that increase amounted to only one one-hundredth of an inch. There could, therefore, be little if any apprehension that guns made after Dr. Woodbridge's system would burst without previous warning, though imperfectly constructed.

In view of the fact that the gun tried stood quite severe tests, notwithstanding its imperfections, and that the plant used in its construction still exists at Frankford Arsenal, it is recommended that another 10-inch gun, after the model presented by Dr. Woodbridge (Plate VI accompanying his letter of March 29, 1882), be made for further trial. It is suggested that the method of strengthening the walls of the gun as against longitudinal strains, shown on his drawing for a 12-inch gun (Plate IV), be adopted in the construction proposed.

Ayes—Major Mendenhall, Colonel Tower, and General Getty—3.

Noes—Major Parker and Lieutenant-Colonel Buffington—2.

With reference to the plan submitted by Mr. B. B. Hotchkiss, through the Chief of Ordnance, the following resolution was unanimously adopted:

The plan of a steel and wire gun designed by Mr. B. B. Hotchkiss, and presented by the Chief of Ordnance, being only of 6-inch caliber, hardly comes within the category of heavy ordnance, while the information given is very meager as to details of construction. It is submitted confidentially to the Board, which alone precludes any official consideration of and report upon its merits. It is therefore respectfully returned to the Chief of Ordnance.

In reference to the plan submitted by the Chief of Ordnance the following resolution was unanimously adopted:

Though the wire gun has had but a limited trial, it seems to promise the strength requisite for the attainment of high initial velocities. The precise combination of parts that will give the best results for steel wire guns has not as yet been arrived at. To reach the solution of the problem it will be necessary to experiment with different gun constructions after this general method, and it is with this view that the Board recommends that the 8-inch wire gun presented by the Ordnance Department be constructed for trial.

With reference to the plan submitted by Dr. W. E. Woodbridge, marked Plate IV, the following resolution was unanimously adopted:

It is the opinion of the Board that the plan of a 12-inch gun submitted by Dr. W. E. Woodbridge (Plate IV) accompanying his letter of March 29, 1882, consisting of steel tubes and bars, strengthened by wire wrapped and soldered, presents a combination and arrangement of material and parts which gives sufficient promise of strength to warrant a trial of this system of construction. The large charge of powder and heavy shot proposed to be used places it in the front rank of high-power guns, and while there may be some doubt as to its ability to endure what is claimed for it, especially with the present arrangement of the two tubes, it is believed that a high-power gun can be made on this general plan, and it is with this view that the Board recommends that a 10-inch gun on this plan be made and submitted to actual test.

The plan of an 18-inch brazed steel wire gun, re-enforced with wire soldered, submitted by Dr. W. E. Woodbridge, marked Plate VII, was laid aside, being of too large a caliber to warrant a recommendation for its actual test, since experiments to test the efficiency of the wire system are but just commenced with guns of 6-inch, 8-inch, and 10-inch calibers.

Pending further consideration of the plans before it, the Board then adjourned to meet the 11th instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, *May* 11, 1882.

The Board met, pursuant to adjournment, at 11 o'clock a. m.

Present: All the members and the recorder.

The proceedings of the 10th instant were read.

The Board continued the examination and discussion of the plans of steel-wire guns still before it.

With reference to the plan submitted by Col. S. Crispin, Ordnance Department, marked Plan I, the following resolution was adopted:

The design for a wire-wrapped B. L. steel rifle gun after the plan of Captain Schultz, French artillery, for securing a division of strains, presented for the consideration of this Board by Colonel Crispin of the Ordnance Department, having already been tried abroad with more or less success, is recommended for test in common with the other designs of wire guns heretofore recommended, with a view to determining the best combination of parts for this general system of gun construction.

Ayes—Major Mendenhall, Major Parker, Colonel Tower, and General Getty—4.

Noes—Lieutenant-Colonel Buffington—1.

Lieutenant-Colonel Buffington stated that he voted *no* for the following reasons, viz:

The line or lines of resistance in any machine should coincide as far a possible to the force or forces to be resisted, which is not the case in this gun, the longitudinal support being far removed from the center. The assembling of the rods for this support around the exterior of the gun is a clumsy and unmechanical construction that may give rise to the necessity of special carriages for its use. Any loosening of the nuts, as is shown by experience in bridge structures using similar rods and nuts, or any giving way of the threads of the nuts or rods, would prove disastrous to the gun and those around it. It is a foreign invention on which royalties may be claimed, possessing no particular advantages over wire and steel guns already recommended by this Board for construction and test. And, lastly, no details of construction and cost for this particular gun are given so that an intelligent opinion may be formed of essential points to be considered before recommendation.

In reference to the plans submitted by Mr. W. P. Hunt, marked Designs O and P, and that submitted by Lieut. C. C. Morrison, Ordnance Department, the following resolution was unanimously adopted:

The plans submitted by Mr. W. P. Hunt, president of the South Boston Iron Company, Boston, Mass., with his letter of April 15, 1882, and marked Designs O and P, and that submitted by Lieut. C. C. Morrison, Ordnance Department, with his letter of April 9, 1882, are not recommended for construction and trial.

The plans, specifications, estimates, &c., presented by Mr. H. F. Mann, of Pittsburg, Pa. (L. R., Nos. 205 and 258), were then taken up for final action, the plan for a 12-inch rifle discussed at length, and the following resolution unanimously adopted:

This gun consists of a cast-iron barrel bound around the powder chamber by steel bands. It is 30 feet in length, weighs 92,000 pounds, and is balanced on its trunnions. The breech fermeture is held to the trunnions by heavy steel straps, the whole arrangement weighing 37,000 pounds additional to the weight of the barrel, giving a total weight of 129,000 pounds. This fermeture is the characteristic feature of the gun, and is the invention of Mr. Mann. The principal objection to it is its great weight, but, further, it necessitates the turning of the barrel of the gun on its trunnions through an arc of about 10° and back again at each discharge, requiring the expenditure of more time and force than for either the Krupp wedge or the slotted screw systems. The piece possesses no advantages over the cast-iron gun bound with steel bands and with the screw fermeture recommended by this Board for trial, unless it be that it gives greater security against transverse rupture. Trials, however, of guns of similar construction, but with the simple screw fermeture, have proved successful within moderate limits of powder pressure—all that is claimed for the design of Mr. Mann, as is evidenced by his powder charge and weight of projectile. The only apparent merit of the structure consists in relieving the body of the gun from longitudinal strains, and transferring them through the attached breech by means of steel straps to the trunnions. But in view of the objections set forth above to the fermeture itself—the specialty of Mr. Mann's invention—this Board fails to see sufficient reasons for recommending the gun for construction and trial.

The plan of a projectile submitted by Mr. H. F. Mann with his letter of November 16, 1881, and marked Plate III (L. R. No. 205), was then carefully examined, and the following resolution unanimously adopted:

The particular merit claimed by Mr. Mann for his projectile is the number, position, and mode of attachment of the bands. The question how these details will affect the strength and penetrating power of the projectile can only be settled by future experiment, and it is therefore recommended that this projectile be tried by the Ordnance Department with others, when circumstances and opportunity are favorable.

The plan of a projectile submitted by Dr. W. E. Woodbridge, with his letter of March 29, 1882, marked Plate VIII (L. R. No. 278), was then examined, and the following resolution unanimously adopted:

The rifle projectile proposed by Dr. W. E. Woodbridge, shown in Plate VIII, accompanying his letter of March 29, 1882, is recommended as worthy of actual test in competition with other projectiles.

The Board then adjourned, to meet the 12th instant at 11 o'clock a. m.

ARMY BUILDING,
New York City, May 12, 1882.

The Board met, pursuant to adjournment, at 11 o'clock. a m.

Present: All the members and the recorder.

The proceedings of the 11th instant were read.

A letter from Mr. H. F. Mann, of Pittsburgh, Pa. (L. R. No. 288), submitting copies of his letters patent and of his remarks before the Committee on Naval Affairs of the House of Representatives, and requesting that they be filed with his previous papers, was read, and the papers filed as requested.

The Board then discussed at length the question of the form and arrangement of its report, and to allow time for its preparation adjourned, to meet at the call of the president.

ARMY BUILDING,
New York City, May 18, 1882.

The Board met, at the call of the president, at 11 o'clock a. m.

Present: All the members and the recorder.

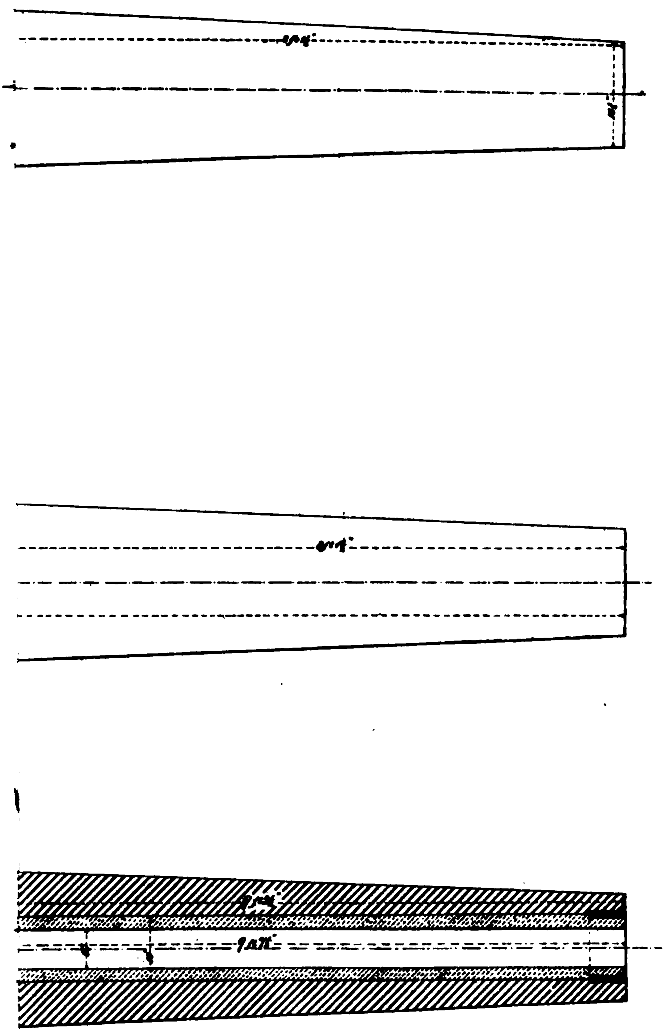
The proceedings of the 12th instant were read.

The report of the Board was then read and signed.

The proceedings of the Board were then signed, and the Board adjourned.

GEORGE W. GETTY,
Brevet Major-General and Colonel Third Artillery.
Z. B. TOWER,
Colonel of Engineers and Brevet Major-General, U. S. A.
A. R. BUFFINGTON,
Lieutenant-Colonel of Ordnance.
F. H. PARKER,
Major of Ordnance.
JOHN MENDENHALL,
Major First Artillery, Brevet Colonel, U. S. A.

F. E. HOBBS,
Second Lieutenant Second Artillery, Recorder.



6 INCH LYMAN-HASKELL GUN

SCOTT FOUNDRY. READING, PA. 1881.

nce & Projectiles.

Appendix 17—1882

APPENDIX 18.

PROGRESS REPORT ON EXPERIMENTAL CANNON POWDERS.

BY CAPT. CHARLES S. SMITH, ORDNANCE DEPARTMENT.

In August and September, 1882, some firings were made with the 12.25-inch muzzle-loading rifle, using two samples of powder, to wit: one marked I. Q., of density 1.804 and granulation of 11; the other marked I. R., of density 1.800 and granulation of 30. The principal object of these firings was to ascertain how great a *length* of charge could be employed without the occurrence of wave action; it being the intention to compensate for the increased *weight* of the charge by suitably regulating the air space, so that with the largest charge that might be employed the normal pressure should be restricted to 37,000 pounds. The length of bore to be occupied by the charge, for a given air space, having been previously calculated, it was laid off from one end of the rammer staff, and to it was added the length of the projectile. By this means a point of reference was established for the position of the projectile, when the piece was loaded. The ignition of the cartridge, with the larger charges, was effected on the interior of the cartridge by means of a brass tube, containing a priming of rifle powder, which was exploded by an ordinary electric primer. The brass tube entered by the rear vent, and penetrated the cartridge to about half its length. This plan answered its purpose very well, though some modification in its application was suggested by the experiments. It could be safely relied on to prevent the ignition from commencing at the bottom of the bore. After firing one charge of 75 pounds with each sample, the I. Q. powder was selected as the one better adapted to the experiments in view, although some firings were afterwards made with I. R. to ascertain its comparative qualities. It was the intention, the pressure permitting, to gradually increase the charge to 200 or 205 pounds, so as to attain a length of bore occupied by the charge of from 5 to 6 calibers, but after reaching the charge of 180 pounds, the I. Q. sample became exhausted, and further experiments in this direction had to be postponed till another lot of powder could be procured. The records of firing with both powders follow. After the firing, the gun was carefully star-gauged and examined, and appeared to be in a good condition.

CHAS. S. SMITH,
Captain of Ordnance.

Record of firing with 12.25-*inch muzzle-loading rifle No.* 1, *August* 30, 1882.

Number of fire.	Time.	Powder. Kind.	Powder. Weight, in pounds.	Projectile. Kind.	Projectile. Weight, in pounds.	Elevation, in degrees.	Pressure, pounds per square inch of bore.	Initial velocity, in feet.	Recoil, in feet.	Number of cubic inches per pound of powder.	Vent used.	Length of projectile.	Length of charge.
29	Aug. 30	Du Pont's square, I. Q.; density, 1.804; granulation, 11.	80	Butler, resaboted	700	½	12,500	1,067	3.67	34.82	Top	30.00	26.20
32	Aug. 30	....do.......	100	Butler, new.	700	½	15,000	1,185	4.75	36.10	..do .	30.75	33.20
33	Aug. 30	....do.......	118	... do ...	700	½	20,000	1,283	5.25	34.83	..do .	30.75	37.45
34	Aug. 30	....do.......	140	Butler, resaboted	695	½	20,500	1,336	......	37.62	..do .	30.00	47.20
35	Aug. 31	....do.......	140	Butler, new.	700	½	20,000	1,360	......	39.60	Rear	29.75	56.45
36	Aug. 31	....do.......	160	... do ...	700	½	21,000	1,404	5.42	35.00	..do .	30.00	50.38
37	Aug. 31	....do	180	....do ...	700	½	29,000	1,508	......	34.00	..do .	29.50	54.50

Record of firing with 12.25-*inch muzzle-loading rifle, August* 31, 1882.

Number of fire.	Time.	Powder. Kind.	Powder. Weight, in pounds.	Projectile. Kind.	Projectile. Weight, in pounds.	Elevation, in degrees.	Pressure, pounds per square inch of bore.	Initial velocity, in feet.	Recoil, in feet.	Number of cubic inches per pound of powder.	Vent used.	Length of projectile.	Length of charge.
30	Aug. 30	Du Pont's Hexagonal I. R.; density, 1.800; granulation, 30.	80	Butler, new.	700	½	16,000	1,132	4.25	37.30	Top	30.00	27.95
38	Sept. 1	....do.......	100	...do	700	½	22,500	1,281	5.17	33	..do .	30.5	......
39	Sept. 1	....do.......	120	...do	700	½	28,500	1,347	......	34	Rear	31.00	......
40	Sept. 1	....do.......	130	...do	700	½	28,500	1,403	5.85	34	..do .	30.5	......
41	Sept. 1	....do.......	140	...do ...	700	½	36,000	1,427	5.94	34	..do .	30.25	......
42	Sept. 2	....do.......	140	...do	700	½	29,000	1,426	5.94	34	..do .	31.00	......

APPENDIX 19.

REPORT ON EUROPEAN ORDNANCE AND MANUFACTURES.

BY COL. S. CRISPIN, ORDNANCE DEPARTMENT.

(30 plates.)

ENGLISH HEAVY ORDNANCE.

(14 plates.)

The built-up gun construction of Great Britain, the germ of which is to be found in the coiled welded system of Sir William Armstrong, introduced to the artillery world in 1852 in the form of a breech-loading cannon, but passing from that date through numerous and important changes, especially the thickening of the coils and the introduction of tempered steel lining tubes, is the one which is still adhered to, in its general principles, by the ordnance constructors, both public and private, of the English nation.

The failure of the Armstrong breech-loading guns, and the subsequent introduction of muzzle-loading cannon in lieu thereof, in 1869, did not change, however, one of the essential features of the present construction—the employment of coiled welded wrought-iron sections—but led to the modified form of their production known as the Fraser system, and the introduction of comparatively thin oil-tempered steel tubes for the interior lining.

The most prominent guns produced under this new system, which first attracted universal attention on account of their great comparative power, were the 25, 35, and 38 ton guns; but these, as is well known, were quickly superseded by the 16-inch 80-ton gun, and it, in its turn, by the largest of, as yet, constructed ordnance—the 100-ton guns of the Armstrong model. (Plate I.)

Regarding the broad principles underlying the construction of the Woolwich guns, the English authorities claim that they produce a system—

> where we not only make each portion of the metal do its proper amount of work by shrinking one coil over another, but also use a tube of stronger material, steel, for the inner barrel. We employ this latter not only because we gain by its longitudinal strength, but more especially because steel gives us a hard, smooth surface, is much stronger than wrought iron, and free from flaws. Its elastic limit is also much greater than that of wrought iron, especially when toughened in oil (as 30 tons to 12 tons), so that it can stand, without deformation, a pressure which would permanently stretch a wrought-iron barrel.

Also:

> In our heavy rifled muzzle-loading guns we thus make use of the several methods employed to make every portion of the metal do its proper amount of work. In this way we avoid, as far as possible, extra weight, and succeed in making guns so strong that we may assert, without fear of contradiction, that in the system of construction now pursued by us, though theoretically it may not be perfect, we have the safest, cheapest, and most simple system of manufacturing heavy ordnance which at present exists.

The theoretical consideration that the ratio of the capacities for work of two tubes is only approximatively directly as their thicknesses, or, generally speaking, that a thin tube has more relative strength than a thick one to withstand interior bursting strains, is the essence of the theory of the built-up guns of the English model, and it is practically carried out in their present constructions; the inference to be drawn being that a homogeneous structure, having no subdivisions in its walls, does not bring into play the full strength of the entire thickness while under stress; and that guns constructed homogeneously, however thick, cannot sustain long, pressures exceeding the tensile strength of the metal employed.

Sanctioning the soundness of the theory that only by built-up constructions the most powerful and yet reliable guns can be produced, the next point for consideration is the arrangement of the different metals entering into the fabrication, so that the stronger metal (steel) shall form the walls surrounding the bore, and that the superimposed layers of wrought iron shall be so placed on, that each part, from the bore to the exterior, shall be, as far as possible, under strain in accordance with its capacity for work, considered in reference to tangential strains.

The English authorities state:

> This object we may obtain by employing a single metal for the several portions, and so disposing the various layers over each other, that the inner layers or tubes are compressed by those outside them, while the exterior tubes are at the same time put into a state of tension, the inner layers being thus strengthened at the expense of the outer portions of the metal. In this case we obtain the whole strength of all the layers except a part of that of the outer and unsupported ring. It must not, however, be for one moment supposed that this theoretical perfection is ever reached; the nearest approach to it is far from perfect, and theoretic advantages have to give way largely to practical considerations of manufacture.
>
> Again, we may arrive at a similar result by employing metals varying in elasticity or in tenacity for the several parts, those possessing the largest amount of strength constituting, of course, the inner portions, so that where the greatest stress is felt, it will be borne by the stronger material.
>
> These two methods are sometimes called respectively those of initial tension and of varying elasticities. They may be, and frequently are, both employed in the manufacture of a gun, as in the case of our so-called Woolwich guns.

The longitudinal strain is provided for by the thick solid-bottomed steel tube, and the breech-plug screwed into the wrought-iron coiled tube superimposing the inner tube, brings into play (in the latest model), the strength resulting from locking the tube and other parts together.

The construction, briefly, we know is a steel tube, over which is shrunk coiled wrought-iron tubes; the majority of the larger calibers, except the 100-ton gun, having only two layers of wrought-iron tubes; the latter more perfectly brings into use the principles of initial tension, by having the wrought-iron casing subdivided into three instead of two parts.

On theoretical considerations, the large number of coils employed in the original Armstrong construction enabled the designers more perfectly to carry out the idea of initial tensions by shrinkage; yet its expensiveness led to its abandonment, and the substitution of larger and, in consequence, fewer coils; thus more imperfectly applying the principles which it was sought to follow as the true ones in making guns. Although economy, the object of the change, was attained, yet it is doubtful, from the large masses employed, if the result is more than a very rough approximation to the asserted theories of construction. The broad differences in the physical properties of wrought iron and steel, *i. e.*, differences in elasticity and ductility and tensile strength, render problematical, it seems to me, the perfect co-operation of the two metals, *under repeated strains* such as attain in the use of guns; and it would seem that the more elastic and less extensible steel, in imparting its stress to the adjacent iron *repeatedly*, would enlarge the latter by degrees, so that eventually it would form but an imperfect support to the former, which would in that case more or less bear, in the system, the burden of the work in resisting tangential strains; and that its rupture under severer treatment would be finally the result. The manner in which this system in manufacture is practically carried out needs only, in view of the full description printed for public use, be but generally stated.

The tubes are generally of Firth's production—a description of which will be given under the general heading of "Steels"—and are furnished under contract at the Woolwich Arsenal. They are solid ingots which are first roughly bored and turned, and then tempered in rape-oil. The jackets or coils, shrunk over the steel tube, in the heaviest natures, range in number according to the length of the gun. Generally two layers of coils cover the breech part, all assembled in accordance with the principle of initial tension.

The details of construction are fully given in English text-books, and need not be alluded to here. The 100-ton gun—the latest English muzzle-loading construction—generally speaking, differs from inferior calibers by the large number of shoulders provided on the steel tube, the latter being made in two parts, united together by a wrought-iron exterior band, and in the greater number of subdivisions of the jackets, or rather that the bands are relatively narrower than on other fabrications; besides, three layers attain at breech, rendering it a more thoroughly built-up gun construction. Four of these guns—made by Sir William Armstrong & Co., Newcastle-on-Tyne—now form part of the armament of Great Britain and her colonies, and now await their emplacements to be prepared for them at Malta and Gibraltar. We are informed that "guns have already been designed and could be readily made at Woolwich, which would surpass the latter (100-ton gun) in power, to as great an extent as they themselves surpass the 38-ton service gun."

The English Government establishment, however, has not produced any muzzle-loading constructions higher than the 80-ton gun, a gun, from the large facilities and perfected machinery of Woolwich, giving us the best exhibit of the Armstrong-Fraser system. (See Plate II.) That no recent attempts, however, to introduce higher natures of muzzle-loading guns have been made, is fully justified, in my judgment, by the important developments of Krupp's experiments at Meppen in August, 1879, and by the disasters occurring on board the English iron-clad the Thunderer in the same year; the first calling attention to the presumed superiority of breech-loading guns—since accorded—in affording less exposure to men; reduced size of embrasures securing greater rapidity of fire; increased length of bore, and hence greater power; and also affording greater facilities for bore examinations, and permitting an ease in loading not afforded in long-bored muzzle-loading guns; and the latter exhibiting the dangers arising from the possibilities of double charging, and the cumbersomeness and complications of loading devices necessary for the use of muzzle-loading guns, more especially in the naval service, where economy of space is a matter of vital importance.

Although the developments at Meppen and the Thunderer misfortune only occurred, say, three years ago, yet such was the moral effect that immediate steps were instituted to develop breech-loading guns of

12-inch caliber and lower natures;* and to-day we find the English authorities, even while the 43-ton gun is yet experimental—having been fired at the proof-ground, and being now at the Woolwich Arsenal for alteration of the screw breech—have in process of construction ten guns of the same type; the Messrs. Firth & Sons, Sheffield, having an order for the steel tubes, which were in process of construction at my recent visit to their works in October, 1881.

These guns will, in all probability, be finished on the original "Woolwich construction"; that is to say, coiled wrought-iron jackets over the steel tubes.

The experimental gun, so far as information could be obtained regarding it, is shown on Plate III.

It will be seen that the gun is chambered, and is calculated to give high initial velocities, and that the system employed is the French fermeture or interrupted screw.

Experiments at Ridsdale proof-ground in August of 1881, with the Armstrong 43-ton gun, may here be alluded to; also comparisons instituted between it and the Woolwich gun of similar weight and caliber, tested at Shoeburyness.

The principal dimensions of the Woolwich and Elswick guns are as follows:

	Woolwich.	Elswick.
Total length of gun without carrier .... inches..	333	331
Caliber .... do....	12	12
Bore:		
In calibers .... do....	26	26
In inches .... do....	312	312.2
Total capacity .... cubic inches..	39,057	38,734
Chamber:		
Diameter .... inches..	15.5	14.3
Length .... do....	58.35	87.43
Capacity .... cubic inches..	10,120	18,178
Diameter in rear opening .... inches..	....	12.4
Rifling:		
Twist, in calibers	(*)	(†)
Length .... inches..	....	220.36
Number of grooves .... do..	48	50

*See Plate X. †1 in 150 to 1 in 45, 10.36 in U.

These constructions (of the same caliber, 12-inch) differ very little from each other in their main features, such as mode of construction, principal dimensions, breech fermeture, and length of bore, the only important variations being in the lengths and diameters of chambers, and their capacities; the Elswick gun (see Table and Plate IV) having a less diameter and a greater length for this part of the bore, and also a greater capacity than the Woolwich pattern; this latter feature increasing the air-space in the chamber of the former over the latter when equal charges are used. It also, for the same diameter of the exterior, gives a stronger gun (both using the same metals) in its walls.

A tabulated statement of these points of difference may be here inserted:

Powder-chamber.		*Powder-chamber.*	
Elswick:		R. G. F.:	
Length .... inches..	86.25	Length .... inches..	58.35
Diameter .... do....	14.3	Diameter .... do....	15.5
Capacity ... cubic inches..	13,178	Capacity ... cubic inches..	10,120

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* An 8-inch gun after this type (Armstrong) has been fired up to September, 1881, 346 rounds, the charges in a great many cases reaching 100 pounds of prismatic powder and the projectiles 180 pounds.

The results of some firings made with the Elswick gun in August, 1881, are tabulated below, and present the main facts as to weights of charges and projectiles employed, and the ballistic effects obtained.

Number of rounds.	Charge.	Gravometric density of charge.	Cubic inches per pound.	Projectile weight.	Observed velocity.	Muzzle velocity.	Muzzle energy.	Pressures.		
								Chamber.		Shot.
								Top.	Bottom.	
	Lbs.			*Lbs.*	*F. s.*	*F. s.*	*F. tons.*	*Tons.*	*Tons.*	*Tons.*
1	275	0.579	47.92	703	1,629 1,624	1,633	12,999	13.2	13.1	12.4
2	300	0.631	43.93	705	1,719 1,712	1,722	14,496	15.15	15.15	12.7
3	325	0.684	40.55	700	1,816 1,798	1,813	15,954	16.8	16.8	13.8
4	350	0.736	37.55	697	1,872 1,857	1,871	16,919	22.2	22.2	19.9
5	375	0.789	35.14	703	1,931 1,920	1,932	18,195	25.1	25.0	22.4

For facilitating a comparison between the results obtained by the Elswick and Woolwich guns—the only essential difference in construction, in a ballistic point of view, between the two guns being the differences in chambering—I have tabulated above the features of the two guns in this regard, and now add here a tabulated comparative statement of different firings from the two rifles:

No. 1.

Gun.	Pressure.	Charge.	Muzzle velocity.	Gun.	Pressure.	Charge.	Muzzle velocity.
	Tons.	*Pounds.*	*F. s.*		*Tons.*	*Pounds.*	*F. s.*
Elswick	13.2	275	1,633	R. G. F	15.1	270	1,795
R. G. F	13.2	250	1,718	Elswick	16.8	325	1,813
Elswick	15.1	300	1,722	R. G. F	16.7	280	1,837

No. 2.

Gun.	Pressure.	Charge.	Projectiles.	Muzzle velocity.	Remarks.
	Tons.	*Pounds.*	*Pounds.*	*F. s.*	
Elswick	*17.1	330	700	1,835	With service charges of 330 pounds for Elswick gun and 286 pounds for Woolwich.
R. G. F	17.1	286	720	1,855	

* Estimated.

No. 3.

Gun.	Pressure.	Charge.	Muzzle velocity.	Gun.	Pressure.	Charge.	Muzzle velocity.	Remarks.
	Tons.	*Lbs.*	*F. s.*		*Tons.*	*Lbs.*	*F. s.*	
Elswick	22.2	350	1,871	Elswick	25.1	375	1,932	Rounds fired with pressures exceeding service limit, using 700-pound projectiles.
R. G. F	17.5	290	1,876	R. G. F	18.9 19.7	300 311½	1,919 1,950	

These results are in favor of the Woolwich gun; and the conclusion is fully waranted that to the larger, shorter, and less capacious chamber of this latter its superiority is due over the Armstrong model. The proof of this is to be drawn from the comparison between two firings with 330 pounds and 286 pounds, with 700-pound projectiles (see Table No. 2), and the results shown in Table No. 3.

With equal pressures (service limitation 17.1 tons), the Woolwich gun gave, with 44 pounds less powder, 835.2 foot-tons more energy at the muzzle than the Elswick; and with 64 pounds of powder *less* (see Table 3), it gave a slightly increased velocity with a marked difference in pressure in its favor. Ordinary prismatic powders were used.

That the form and dimensions of the chamber have, independent of the mere fact of the employment of a well established air-spacing to produce the maximum power, with due regard to standard, or say safe pressures, an important bearing in the attainment of the maximum muzzle energy or gun power, with a given weight of powder and projectile, it is only too apparent from the above quoted results; the shorter and larger diametered charge-receptacle having a decided advantage over the longer and smaller diametered and more capacious one. The air-spacing, it will be seen, is different in some cases of comparison, but in the firings with pressures exceeding service limits—which is of no consequence as far as the comparison of chambers is concerned—it will be seen that the air-spacing was about practically the same in both cases, and the results broadly in favor of the shortened charge-receptacle.

In the theories generally advanced regarding the introduction of chambers, the stress is generally laid principally on the beneficial effects of the mere proper air-spacing, and that the shape and dimensions of the chamber have a powerful influence in the admission of the use of relatively large charges, without excessive pressures, is almost lost sight of in the discussion. With about equal air-spacing, the Elswick gun (see Table 3) gave an increase of 5.8 tons pressure over its competitor, and with the attainment of no greater velocity, and with the use of a considerably larger quantity of powder. This result must be solely attributed to the form of the chamber; and the English authorities at Woolwich have recently been making every effort to shorten the chamber, and to secure the proper space for the charge (sufficient data is not yet obtained as to the proper air-spacing), by proportionally increasing its diameter, and to proceed in this direction until the best results are obtained at the proof-ground. With this end in view, the 43-ton gun—experimental—was at Woolwich in October, 1881, where it was being enlarged at the breech to receive a chamber, which, in accordance with views deduced from their experiments, is better proportioned, in order to secure increased effectiveness, using slow-burning powders.

Long, thin cartridges, such as the Elswick pattern, would, it is considered by those best informed, to obtain the best results, have to be used with a larger air-spacing, and have a slightly quicker burning-powder than the Woolwich gun; besides, it has been well established that "wave" action and resulting abnormal pressures arise in the use of very long charges.

Even our own limited experiments made at Sandy Hook indirectly show that the introduction of a chamber, *i. e.*, an enlargement of the diameter of bore (where the powder charge is consumed), is of essential importance, in enabling us to use (according to modern practice) large charges with safety to our guns (see table).

Number of rounds.	Charge.		Weight of shot.	Windage over cartridge.	Mean.	
	Kind of powder.	Weight.			Velocity.	Pressure.
		Lbs.	*Lbs.*		*Feet.*	*Lbs.*
1	Hex., E. V. J.; dens., 175; gran., 72.	*35	180	Service windage about $\frac{1}{10}$ of the diameter of the bore.	1, 382	30, 500
2	..... do	30	180	Service windage.....	1, 258	20, 000
2	..... do	30	180	Service windage reduced 50 per cent	1, 263	23, 000
2	..... do	30	180	None	1, 344	25, 500

* Service battering charge.

Gain due to entire suppression of windage: Velocity, 86 feet; pressure, 5,500 pounds.

Here we see that by air spacing, using one-tenth of the diameter of the bore (in an unchambered gun), the gain in velocity is only 36 feet over the use of the same charge in which no air-spacing is admitted whereas the pressures are increased nearly 20 per centum.

Mere air-spacing proper, *per se*, it would appear, gives but little, if any, practical advantages, judging from these results, and they only give additional proof that our modern success in the employment of large charges results, speaking in general terms, from a combination of an enlargement of the bore for the charge to rest in (and to the dimensions and form of the resulting chamber), with the employment of a proper windage or air-spacing.

These views lead me to express my belief that the shape and form of the chamber controls the combustion of large charges, and also the passage of the powder-gases from the chamber into the bore.

Pertinent to this view of the case, attention is invited to the following remarks to be found in Ordnance Notes, No. 105, to wit:

> It is deemed important to keep up the tangential strength of the system to a considerable distance beyond the seat of the charge, as the circumstances of inflammation and subsequent combustion of it (large in weight) would seem to demand a considerable length of bore of the maximum strength, as pressures approximating to the maximum must attain longer than in ordinary cases; or, to illustrate otherwise, the curve of pressure must be relatively much flatter than that attaining in the use of a common charge. Also, it is believed that the action, in the case of the employment of chambers with large charges of powder, results at the time of the initial inflammation of the charge in the development of a powder-gas comparatively low in pressures, owing to the space above, but sufficient, however, with the compressed air, to start the projectile with a low velocity; and that when the maximum pressures attain, the volume of the bore between the burning powder and projectile is relatively greater than under ordinary circumstances, and that the phenomena of a rapidly-augmenting gas evolution giving increased power ensues; but, owing to the rapidly-increasing velocity of the projectile, increasing rapidly the bore spaces between the burning powder and the shot, the resulting pressures decline gradually from the maximum (not usually dangerous); and, hence, with long bores the capability of thorough consumption of large charges with moderate pressures resulting, and with high initial velocities, are within our reach.

The large charges now employed, some of them with guns of comparatively light weight, as, for instance, the use of 300 pounds of powder with 400 and 500 pound projectiles in a 21-ton 10.15 inch gun (wire), necessarily results, even with the use of chambers and in an "air-spacing" adopted as the best to secure the maximum effects with minimum strains, in enormous pressures; and we can *only* expect to increase our quantities of powders in chambered guns up to that point where we do not exceed the limit of safety *established*, in material and design, for the gun construction employed.

The Woolwich authorities have established 17.1 tons per square inch as the service limit for pressures, yet Armstrong for his constructions reaches 25 tons per square inch, and in his 10.15 inch wire gun a pressure of 34 tons per square inch has attained.

Cast iron alone, or cast iron in combination with wrought, or with wrought iron and steel, or with steel alone, in guns for, say, one caliber and a half thickness of walls, cannot endure the chambering; and in consequence, the increased charges which constructions made of steel alone, or steel in combination with wrought iron, can sustain; and hence any plan using the inferior metal looking to a rivalry with the superior modern constructions which ignore the use of cast iron, would be a risk too hazardous to assume, and when the pressures reach, in guns using cast iron, a limit of say not exceeding 35,000 to 37,000 pounds for a gun one and one-half calibers thick, the service limit should be regarded as reached, and the charges and chambering should be so regulated as to keep within these limits which should be established as the limits of safety.

This leads me to remark that the guns recently experimented with at Sandy Hook, to wit, two 8-inch breech-loaders and one 11-inch breech-loader (converted), were all probably too largely chambered for the strength of the constructions, and hence prompts the belief that in constructions where cast iron is used, the weakness of this metal should lead to the employment of moderate chambering as compared to the chambering of the powerful light-weight guns made of steel in some of its forms, or in combination with wrought iron, which are now in vogue with the most skillful and farthest advanced gun constructors of Europe.

Regarding constructions in which a caliber and one-half is taken as the thickness of walls required, it would seem that in the introduction of chambering that an increase to one and one-half calibers of metal should attain in surrounding it; in other words, in a 12-inch caliber with a 14.3-inch chamber that the increase of the exterior diameter at the seat of the chamber over the unchambered 12-inch gun should attain so as to make our constructions in conformity to the established practice.

In steel guns a little less than one caliber is regarded as sufficient thickness of walls; and a caliber and one-quarter, about, is used over the chambers of the 43-ton guns composed of steel and wrought iron. In steel-tubed guns, surrounded by a wire and a part steel and part wrought-iron jacket, the thickness of walls given over the chamber is but eighty-five one-hundredths of a caliber. These figures illustrate the vast difference in the eyes of European gun constructors between the use of pure steel and the combination of steel and wrought iron, and more especially in any construction in which cast iron plays a prominent part. It would seem, therefore, independent of the recognized fact of the inferiority of cast iron in strength, that the important element of weight would become largely a factor for consideration in judging of constructions using this metal, either alone or in combination with others. In fact, as much power can be secured from a 43-ton (12-inch) gun (steel and iron), as from a 12-inch, 55 to 60 ton gun (built up), of cast iron and steel.

In a 44-ton (13 inch) wire gun (Plate V) we have the remarkable exhibit of a yield of 27,460 foot-tons muzzle energy, or say 637 foot-tons per ton of metal. The cast-iron and steel constructions (60 tons) alluded to above only give 359 foot-tons per ton of metal. The 10.15-inch wire gun recently constructed has been tested, and the distinction between it and the last-mentioned gun is more pronounced in favor of wire than the 13-inch; the resulting muzzle energy giving 760 foot-tons per ton of metal. The pressures are relatively higher in attaining these results, yet the strength of the combination is believed to warrant a large increase over the ordinary standard pressure adopted for the guns of the English service.

Admitting that about 27,600 foot-tons muzzle energy can be attained with a 13-inch of a weight of say 44 tons (wire), we find that it takes 50 per centum more weight (60 tons) in a gun (12-inch) using cast iron to attain a much less muzzle energy corresponding to the difference in calibers.

The force of this testimony regarding weight is evidently, as far as it goes, against the use of cast iron; and when we consider the question of its employment, pure and simple, this objection of increased weight necessary in the structure, becomes a subject of the first importance, and one alone which at the threshold of the consideration of the problem of gun construction should lead us to doubt if it should be employed at all if we desire to attain a high standard in power and endurance in our future heavy ordnance armaments.

Independent of strength and increased weight, cast-iron guns of heavy natures require a cumbersome and expensive plant, consisting of deep pits, large furnaces, powerful cranes, and heavy and powerful lathes, &c., whereas in the built-up steel, and steel and wrought-iron systems, also wire guns, the numerous parts which go to make up the whole, can, from their comparative lightness, be handled in the different operations of construction with far greater ease, and less expense than attain in the production of homogeneous masses consisting of but one piece, as found in systems where cast iron enters either solely or largely into the fabrications.

On the score of economy, it may be doubtful if any material advantage results in the use of cast iron. English models cost about 14 cents per pound. To gain equal powers we would require, according to the ideas of constructors in cast iron, at least a 60-ton gun to perform the same work as a 43-ton gun of steel and wrought iron. If we estimate cast iron at 12 cents per pound, we have a cost of $16,128 for a pure cast-iron gun of 60 tons; and admitting 14 cents per pound for wrought iron and steel, we have a cost for a 43-ton gun of $13,484.80. If a net profit of 25 per centum for manufacturers is added to this latter figure, which is government cost, we have even then a less expensive construction than pure cast iron in that country. (See below.)

Regarding the use of cast iron in the English service, it was practically abandoned in 1864. A full report of the ordnance select committee of that year is quoted below as having a bearing of some interest, not on this question alone, but on others which concern the present condition of the heavy ordnance problem in the United States.

Ordnance Select Committee.

Subject: Question as to the construction of heavy guns of some cheaper material than wrought iron:

The committee have been directed to give their early and earnest attention to the question of providing some cheaper mode of construction for heavy guns than that at present adopted, looking to the probable introduction of a large number of such guns for coast defenses, and to the importance of reducing the expense which would attend their supply, if made as at present.

In considering this question, the committee have contemplated each of the following alternatives:

1st. Guns to be made of cast iron alone.

2d. Guns to be made up of combinations of cast iron or steel, which again may be subdivided into two classes:

a. Cast iron, strengthened externally by hoops of wrought iron or steel, like the Parrott and Brooke guns of America.

b. Cast iron, strengthened internally by lining them with wrought-iron or steel tubes.

3d. Guns made of wrought iron, but of cheaper quality in the exterior coils than has been hitherto employed, and of less expensive construction.

1. Guns of large caliber made of cast iron only.

With regard to the first of these constructions, viz, the employment of cast iron only, the committee reject it on the grounds that guns of this nature cannot be relied on to resist the strain due to such charges as are necessary to produce sensible effects when fired against iron structures.

Cast-iron smooth-bored guns of large caliber, such as the 13-inch and 15-inch Columbiads, have been constructed in the United States for the defense of passages a mile or so in width, but notwithstanding the experience of the Americans in respect to mixtures of iron ores and methods of casting which has enabled them to produce guns of very superior quality, they have been obliged to limit themselves in great measure to the use of relatively small charges of powder and hollow projectiles, and are consequently unable to avail themselves of such high velocities as it is desirable to give to projectiles for penetrating armor plates. In order also to compensate for the want of accuracy common to smooth-bore guns, it has been the practice in America to arm special localities with these large pieces of ordnance in extraordinary numbers, thereby incurring as much expenditure as would suffice for the provision of a smaller number of efficient rifled guns of wrought iron.

For the above reasons, and believing that it is practically impossible to raise the quality of the cast-iron guns supplied by the great gun-founding firms in any material degree, the committee are of opinion that the question of employing cast iron alone for the construction of heavy guns must be set aside.

2. Guns made up of combinations of cast iron and wrought iron, or steel, which embrace the following classes:

a. Cast iron strengthened externally by hoops of wrought iron or steel.

The committee reject this mode of construction, on the ground of the very little success which has attended any of the various methods proposed in this country to give additional strength by means of external hooping. Although the Americans have introduced their 8-inch and 10-inch Parrott guns, which are constructed on this principle, their general serviceability is by no means proved, as yet. On the contrary, the experience gained at the siege of Charleston tends to confirm the opinion that little or no confidence can be placed in such constructions, even when comparatively moderate charges are used. The committee are informed that at that siege, out of about 42 guns, 23 or 24 burst after an average life of 240 rounds.

b. Cast iron, strengthened internally by lining with wrought-iron or steel tubes, or made by casting iron over wrought-iron or steel tubes, on the plan proposed by Captain Palliser and others.

The plan of lining cast-iron guns with wrought-iron coiled tubes has been tried with encouraging results, and should the experiments now on hand with a 68-pounder cast-iron gun, reduced by internal lining, on Captain Palliser's plan, to a 7-inch caliber, and rifled, give good results, there will be a number of 68-pounders and 10-inch guns which may be made available for rifled guns weighing from 100 to 200 cwt.

This construction, however, does not touch the question of the heavier guns, and although Captain Palliser expresses every confidence in being able to apply it to large guns capable of resisting heavy charges by casting iron around wrought-iron tubes, the committee do not at present recommend experiments to test the efficiency of his method, on the grounds that it appears to be less economical than a gun constructed wholly of wrought iron, only employing a cheaper quality for the external hoops or coils.

The committee have discussed with the superintendent of royal gun factories the question as to the possibility of effecting a reduction in the expense attending the present mode of constructing wrought-iron guns, and he has favored them with estimates of two constructions (A) and (B), by which this object will apparently be obtained.

Without expressing any positive opinion as to the probable endurance of guns constructed on these cheaper systems, the committee have reason to think that there is every probability that they will be found strong enough for every practical purpose. There is now much reason to believe that some of the cheaper qualities of iron are more suitable for welding than the more expensive natures; and as the longitudinal strength of a coil depends upon perfect welding, there is every promise that no great loss of strength will be incurred when the cheaper iron is in part employed; while a further and considerable saving in material and labor will be effected by reducing the number of the coils themselves.

The committee submit two tracings, marked (A) and (B), showing the cheaper constructions proposed for experiment, together with an estimate of the same, and estimates of the cost of the present mode of manufacture and that proposed by Captain Palliser, for comparison. They are as follows:

Gun, 9-inch, 12¼ tons, with steel inner barrel, as at present manufactured in royal gun factories:

Steel tube	£304
Gun iron, 16 tons, at £22	352
Scrap iron	20
Coals	90
	766
Labor, including incidental departmental expenses	321
Total	1,087

Gun, 9-inch, 12¼ tons, with steel inner tube, as now proposed for experiment, marked (A):

	£	s.
Steel tube	304	0
9¾ tons of iron, at £10	97	10
Scrap iron	16	0
Coals	10	0
	427	10
Labor, including incidental departmental expenses	196	10
Total	624	00

Gun, 9-inch, 12¼ tons, with wrought-iron tube, of Marshall's iron, as now proposed for experiment, marked (B):

Tube, iron, coals	£271
Labor, &c	211
Total	482

Gun, 9-inch, 12¼ tons, coiled tube, and cast-iron exterior, as proposed by Captain Palliser:

Tube, iron, coals	£310
Labor, &c	290
Total	600

Thus it appears that if these estimates prove correct, guns may be made wholly of wrought iron at less than half the cost of the present construction, and of wrought iron over a steel barrel, at less than two-thirds of their present cost.

As regards the former of these plans, nothing would be gained, in point of economy, by adopting a cast-iron exterior; on the contrary, such a gun would cost one-fourth more; and as compared with the latter of them, the saving would be less than £100 per gun, which is too inconsiderable to be set against the advantage of having nothing but wrought iron in the gun.

The committee are informed that this cheaper construction is not untried, one 9-inch gun having been so made.

They think, however, it would be hazardous to go largely into it at once; but they recommend that the superintendent royal gun factories be authorized to make one gun of the 17 9-inch, 12-ton guns ordered on each of the plans (A) and (B), completing the remainder of the supply, and any other guns ordered to be put in hand at once, on the present approved plans. By this means the working of the proposed new arrangements, and the qualities of the new iron, will be satisfactorily tested without delaying their general employment more than a year.

They do not recommend a further trial of guns with cast-iron exterior, until the three cast-iron guns lined with wrought iron for Captain Palliser have been fully tested.

[NOTE.—The cast iron for gun constructions in England has a tensile strength ranging from 9 tons to 14 tons. (See Text-Book 1879.)]

One of these guns is rifled to a 7-inch caliber, and is to fire 1,000 rounds with service charge. The other two are smooth-bored to 68-pdrs; should all three be quite successful, this additional proof of the value of the construction may, perhaps, warrant a trial of it on a 12-ton gun.

Heretofore allusion has only been made to the Woolwich-Armstrong type of construction; but the growing tendency to admit the superiority of steel for external tubes as a substitute for wrought-iron ones promises to rapidly supersede the use of the latter metal in heavy ordnance, both in government and private establishments.

The Royal Gun Factory are experimenting with steel for hoops; and specimens of forged steel of their own product were on hand in October, 1881, and from the blocks planed, showing the evenness and homogeneity of the product, it is judged that good success has been attained.

The introduction of steel hoops in lieu of wrought iron will perfect the English system, and place it among the most prominent of the more advanced ones of the present day.

The steel tubes of their present construction are the product, as before stated, of the steel works of the Messrs. Firth & Sons, of the Norfolk Works, Sheffield. The ten tubes for 43-ton guns—after the Woolwich model—are now under way, and one was under the process of forging at my recent visit to this establishment.

It is claimed by the representatives of cast iron in this country that it has never been tested using the slower burning and large sized grained powders now in vogue. Guns, made of any material, should evidently be so constructed in dimensions and chambering as to cope in power and effectiveness with their rivals, caliber for caliber. In order to do this large charges would necessarily have to be employed with cast iron, and however judiciously air-spacing and chambering may be done, and even using the most perfect powders, the pressures resulting from the large masses consumed would rise beyond what is ordinarily deemed a safe pressure (17.1 tons per square inch), even for guns using steel and iron. To illustrate: The two Armstrong 10.236-inch wire guns (Plate VI) have been fired 60 rounds, and the pressures have been 67,000 pounds per square inch. This is not deemed by author ities on these matters as safe for any of the ordinary constructions now in use, and cannot hence be regarded as by any means a safe one for cast iron, however thick the walls are made within the limits of reasonableness of weight, and hence, although its use might have been entertained as possibly a safe structure some time ago, when large charges in stronger gun constructions did not attain, the conclusion has now to be drawn that no good reasons, even on the grounds of insufficiency of trial, exist for the further test of a metal which, owing to high pressures, will be unable to cope in power, gun for gun, with stronger systems susceptible of enduring the enormous strains arising from heavy charges, and which are beyond the capacity of cast iron to withstand.

It is not understood that any important modifications are at present intended in the general features of the present constructions using wrought-iron exterior tubes, the change being confined principally to the substitution of the one metal for the other. The change has, however, so far progressed and been so well established as an improvement, that steel coils for 80-ton guns have already been produced at Woolwich, and applied in the more recent fabrication of these heavy pieces; the heaviest products, in fact, as yet turned out by the Royal Gun Factory. Eighty-two guns, all steel, were in the works at Woolwich in October, 1881.

Besides these products, such is the urgency of the pending changes to all steel constructions and breech-loading systems, that, having anticipated the thorough trial with the 43-ton gun, ten more guns after the same general plan, it is understood, as before stated, are now under way; and in addition, as far as the change to breech-loaders is concerned it may be mentioned that an order for seventy-seven 6-inch steel guns with wrought-iron jackets is now in process of execution at the government works.

The permanent features of the Royal Gun Factory have been but little changed since 1873, except in the completion of the 100-ton steam hammer, the foundation for it then being far advanced in progress.

Although the steel tubes were principally the product of Firth, yet recently large orders, I am credibly informed, for 8-inch tubes, 21½ feet long, for use in the royal factories, have been intrusted to Sir Joseph Whitworth; and it would seem from this fact that there is a rapidly-growing tendency to regard fluid-compressed steel as a superior steel for gun constructions.

All tubes being procured by contract with the different steel producers in Great Britain, are delivered at Woolwich as solid ingots, and, of course, untempered. The facilities at this place are ample for all needs for tempering in oil. The general details of this process as practiced at Woolwich have been published in the English text-books, and need not be in consequence described in this report.

The effects of oil-tempering are to increase the hardness, tensile strength, and elastic limit of the metal, but somewhat at the expense of its ductility. It is a process, however, which is applied to all steel products for heavy ordnance in England, and also in France, and has been so long practiced, with confidence in it remaining so long unshaken, and, in fact, increasing, that it must be recognized as probably an important process to be employed in constructions where steel tubes of about equal diameters throughout their entire length are designed for use in built-up guns. For ingots, however, wherein unequal diameters find place, the process becomes one of doubtful benefit in its application, as it evidently disturbs the molecular conditions of the metal; sections of different diameters being unequally acted upon by the tempering process, injurious strains are introduced similar to those produced by unequal cooling in masses of cast iron, where the areas of adjacent cross-sections are sensibly and abruptly different.

The increased hardness and diminution of the percentage of elongation in the metal introduced by the application of the process are subjects for consideration, and should leave the question of tempering, in my judgment, one for consideration and further experiment.

The increased tenacity and hardness secured by the process was a matter of great moment to the English constructors when the Palliser stud system of projectiles was standard in the British service, as the enormous strains brought to bear on the bearing edges of a few deep rifle grooves required these qualities to be present in the highest degree attainable; but now, when the Palliser stud system for securing rotation is a thing of the past, it remains to be considered if the merits of the oil-tempering process should not be further inquired into, both theoretically and experimentally, if practicable, and the result may be that a modification of the process, securing an increase in toughness and tenacity to a more limited extent, may be attained without sacrificing too much the extensibility of the metal, which, by permitting a *yielding* at the critical period in gun practice with high pressures, instantaneously produced, adds largely to the ability of the construction to withstand the effects of those powerful, dangerous, and suddenly-applied strains.

The steels used have not changed in qualities since 1872, and about the same physical properties obtain now as then, as exhibited by their tests. A soft steel of about 31 tons per square inch at the breaking point, and when tempered in oil raising to 47 tons, is now, from the latest information in print, about the standard required at the Woolwich arsenal. The untempered steel reaches its elastic limit at, say, 13 tons per square inch, and the tempered at 31 tons per square inch. It is thus apparent that the oil-tempering not only increases the tensile strength of the metal, but also increases in a much greater ratio its elasticity.

It is stated on good authority that no standard of heat required for tempering has been established—different specimens requiring different heats—and hence tests for the required temperatures are made for each tube from specimens taken from their ends. The more hammered steels require less heating than the less denser or softer ones, and hence the degree of heat required varies in every case, depending on the grade of the steel under treatment as to its physical properties as determined by tests.

Two 80-ton guns, completed, are also at Woolwich, to form the armament of the Dover Pier.

The capacity of the Woolwich arsenal, it may be, however, here remarked, is ample, it is believed, to make heavier natures than 100-ton guns; and in fact higher powered ordnance has been projected and within the capacity of these government works.

Steel is favored, as above remarked, for heavy built-up guns; and I am informed that wire constructions are being designed, and that a wire gun with a steel core will be one of the productions at the arsenal in the immediate future.

The Elswick Works of Sir William Armstrong, at Newcastle-on-Tyne, next deserve consideration. They have produced the largest constructions in England of their well known type, and from which sprang the modified form known as the Woolwich gun.

The general plan of their works is, as a matter of some interest, attached to this report. (See Plate IX.) The general features of the works as at present established are given in the following extract from The Engineer, of July 22, 1881:

> *Present condition.*—We give herewith a plan recently made of the Elswick Works. It will be seen that they cover an area of ground lying between the river Tyne and the railroad; alongside the latter runs also the high road and tramway from Newcastle to Scotswood. The facilities for transport are therefore unusually great. We do not attempt to give any sketch of the works, because, as may be surmised from the plan, they are too extensive to admit of any satisfactory general view being taken. The east end is devoted chiefly to ordnance work, the west end being the so-called engine works, where the engineering structures we have described, such as bridges, iron light-houses, dock machinery, and hydraulic machinery are made. The offices are between these two departments, and the principal road and jetty near the middle point. We do not propose to attempt to give a description of the works in any general sense, but merely to notice a few features such as characterize the works, or should be noticed by visitors to Elswick, especially engineers, who may have a special opportunity this summer of visiting these works. We suppose the works to be traversed in the order adopted, as far as we understand, on the last public day.
>
> Commencing at the point forming the right-hand top corner, or N. E. corner of plan, the first objects of interest are the 6-inch and 40-ton breech-loading gun mounted en barbette. The method of mounting and working is shortly noticed above. It is well to observe the system in action and the cover afforded to the detachment. Close to these guns is a shrinking pit for ordnance from the 100-ton gun downwards, also nineteen gas-producers for furnaces. The shops then may be taken in the following order:
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> *Coiling* (No. 32).—The largest section of bar has been 12 inch x 10 inch; length of coiling furnace, 180 feet; gas furnace for heating barrels, also for tempering, with an oil well 50 feet deep, over which stands a hydraulic hoist.
>
> *Forge* (No. 28).—The large hammer here, made by Thwaites & Carbutt, Bradford, has a 48-inch cylinder and 12 feet stroke: weight of piston and hammer-head, 35 tons. Blast smelting furnaces, one furnace building, two in work, and running from

900 to 1,000 tons a week, chiefly No. 1, 2, and 3 pig, made from Spanish and Elba ores, most of it sold for steel-making. The blast is at present heated by horseshoe pipes, but Cowper's heating stoves are in course of erection; temperature of blast, from 750 to 800—about the melting point of zinc. The engine for the furnaces is made by the firm.

Carriage shed (No. 29).—There are band-saws cutting iron which may be noticed, and Albini carriage on short recoil and self running-up system.

Projectile store (No. 33).—Containing finished projectiles. These are chiefly made with bands only up to full diameter, which saves work, and leaves to the projectile the strength of the uninjured skin of the casting. The Palliser chilled projectiles will be generally found with sharp-pointed heads struck with two diameters ogival.

Foundry (No. 27).—Containing ten cupola furnaces, of which four are generally in work. Forty tons is about the maximum weight of casting made in the foundry—a much larger one, such as the bed of the steam-hammer, weighing 137 tons, being cast on its own ground.

The system of hydraulic cranes should be noticed. They are fixed so as to work in pairs, or three together, for heavy work.

Engines.—Near this are the engines for the east works, and also those for the west ordnance works. Horizontal double Corliss engines are employed, with four boilers; three working at a time. Juke's bars and system of stoking is applied to all.

The jetty may probably be conveniently visited next, near which are more horizontal engines, 100 horse-power, working on the accumulators; the water pressure maintained is about 700 pounds per square inch. Five or six locomotives are generally employed in the works. On the east end of the jetty are two fixed hydraulic cranes for lifting 5 tons and 30 hundred-weight; and between them, large hydraulic shears, made by Day & Summers, worked by a direct acting hydraulic cylinder, 40-foot stroke, lifting 120 tons. The bag leg moves so as to bring the lifting cylinder about 30 feet out, 15 feet inboard of a vessel. The foot is moved by a screw 50 feet long, with hydraulic engine and gear, with three different powers. Along the jetty run pipes with hydrants from 18 to 36 feet apart, on which work five movable cranes, each lifting about 30 hundred-weight, being placed in position to suit the holds of the vessels by means of telescope tubes attached to the nearest hydrants.

The finishing shop (No. 14), may be taken next in order. The proportions of new type guns should be noticed also; the breech-loading fittings, and apparatus for firing by electricity, and also mechanically.

No. 12 shop is for small machine work, completing Gatling machine-guns, hydraulic valves, &c.

No. 26 is a machine-shop containing planing-machines, &c.

No. 2 may come next, chiefly for turning, finishing, and boring work, commencing on the solid ingot. At the east end, guns are bored vertically in a pit 23 feet deep.

No. 11 is a large machine-shop for turning, boring, and rifling. The finest lathe is one of Whitworth's for turning, boring, screw-cutting, and rifling, taking a job 44 feet in length, 36 inch centers. There is also a convenient one made by Fairbairn, Kennedy, & Naylor, modified at Elswick, taking a chuck job 20 feet in diameter, 4 feet 6 inches long, or a job 34 feet long and 8 feet in diameter. It is fitted with slide rests on independent beds. There are chambering and rifling machines.

There may be steel ingots here deserving of notice, such as one now waiting between operations, supplied by Vickers, 32 feet long, for a 13-inch breech-loading gun inner tube, and a steel tube replacing the "2 A" coil for 100-ton gun, supplied by Whitworth. Close by this building is another Corliss engine, 169 horse-power.

No. 4. Forge: Crank-shaft, and gun work, coil welding, &c., performed. The steam-hammers here, from 24 tons to 15 cwt., chiefly Morrison's make.

No. 1. Small machinery, turning and boring out short coils. There is a large endless band-saw, 1¼ inches wide, which cuts directly through iron cylindrical work about 16 inches in diameter. Its speed is from 76 feet to 129 feet per minute.

It will be seen that the facilities of these works are ample in every respect for ordnance constructions; and when we come to consider the decidedly advanced progress (to be hereafter mentioned) in the adaptation of steel in its strongest form—ribboned—in gun constructions of light weight combined with great power, it must be admitted that in the pure question of the building-up of guns to resist the drafts upon them, especially by tangential strains, far beyond standard limits in England, Sir William Armstrong & Co. are farthest advanced as the pioneers in Great Britain of a system destined, probably, to solve in the most satisfactory manner the problem of heavy gun construction, in the present state of the art, in producing the metals deemed most suitable for making sound and reliable ordnance.

The ordnance works were in active operation during my visit in October, 1881, and various parts appertaining to guns were in process of construction. On hand, or in process of completion, or ordered at the time, were muzzle-loading and breech-loading guns of various calibers, to wit: 6-inch and 8-inch new modeled breech-loading guns; a 100-ton breech-loading, 17 inch caliber; a muzzle-loading gun of the same weight, with a caliber of 17.75 inches; ten 8-inch breech-loading 26-ton guns, Armstrong coiled system; two 43-ton breech-loading guns of the ordinary Armstrong type (steel tube with coiled jackets); two 10-inch 26-ton guns, and a 44-ton breech-loading 13-inch ribboned gun. Two 21-ton 10¼-inch guns had been almost completed, and have since been tested with results which will be found noticed further on in this report.

Sufficient allusion has been heretofore made to the ordinary Armstrong construction as represented in its highest type—the 100 ton guns—as built at the Elswick Works, both for the English service and Italian navy. This system, like its kindred one, the Fraser, has, in all probability, more than an adequate amount of tangential strength for the heaviest charges, but it may be a question if it has a surplus, or even a sufficiency, of longitudinal resistance to meet the requirements of modern ideas as to the necessities of using large quantities of powder relatively to former usage, and the extra demands for strength arising from this cause.

The principal portion, if not all, the longitudinal stress is borne by the steel tube, the wrought-iron hoops only giving such assistance along the length of the tube as arises from the grip from shrinkage. The Woolwich gun is an improvement in this respect, as the wrought-iron jackets are so united as to afford a greater degree of longitudinal support to the interior tube. The introduction of chambers considerably increased in diameter relative to caliber gives rise to conical surfaces at the bottom and top of the powder receptacle, and leads to an additional amount of longitudinal stress not finding place in the unchambered system heretofore made, and now superseded by the present types, both for muzzle-loading and breech-loading rifles.

The accident on the Italian iron-clad Duilio—the longitudinal rupturing of a 100-ton gun—tends to lead at least to the inquiry if a sufficiency of longitudinal strength is found in the system to meet all the abnormal results (such as wave actions in combustion of charges) which can possibly arise in gun practice with the comparatively enormous calibers of the present day. Even if it was deemed safe to trust the present provisions for longitudinal strain for all possible contingencies of the development in firing of dangerous and high pressures, yet it would seem that a different arrangement, promising the attainment of increased strength in all directions, should be considered.

The introduction of a tempered but thin auxiliary tube of sufficient thickness of walls to provide for the chamber, and probably provide a few calibers' increase of length by protruding at the muzzle, would, it is thought, enable us to secure a better construction, not only for longitudinal but tangential strains. The tube having no bottom would only be subjected longitudinally to a forward thrust from the pressures on the throat of the chamber and the frictional drag of the projectile.

The breech block will find place on the superimposed steel section of a calculated strength to fully sustain the longitudinal thrust which takes place by strains operating from a *point d'appui* at the bottom of the bore, or rather on the surface of the fermeture. The last modeled French constructions, built up and only using steel, are so designed. They will be further alluded to when reference to French heavy ordnance is made.

The most prominent recent developments at the Elswick Works are the experiments with and the production of wire or "ribboned" guns. The successful test of a 6-inch gun of this type has led to the fabrication of 10.236-inch and 13-inch calibers, respectively, the former having only a weight of 21 tons, and the latter a weight of 44 tons, thus securing a gun of much greater power than the 12-inch 43-ton gun of the ordinary Armstrong type.

Preliminary to a description of these novel constructions, the following remarks of Sir William Armstrong on this subject, found in his "Presidential Address to the Institution of Civil Engineers," printed January, 1882, may be of interest, and the attention of the Department is accordingly called to them:

> But the problem is ever before us how to lessen the weight and increase the power of heavy ordnance, and we cannot rest satisfied with results, however good, if they be not the best that appear to be attainable. In saying this I am led to speak of a system of construction which has not yet passed through the experimental stage, but which, from the results it has already given, promises to attain a wide application. I refer to that system in which the coils surrounding the central tube consist of steel wire, or ribbons of steel, wound spirally upon the tube. To those who object to welded coil tubes on the ground of supposed deficiency of longitudinal strength this mode of construction must appear especially faulty, inasmuch as lateral adhesion, instead of being, as contended, merely deficient, is altogether absent, while to those who advocate the present coil system this variety of it must commend itself as affording the greatest possible amount of circumferential strength that can be realized from the material employed. Steel in the form of wire or drawn ribbon possesses far greater tenacity, and also greater toughness, than in any other condition; and in applying it to guns we have perfect command of the tension with which each layer is laid on. The idea of using wire for this purpose is far from new. It formed the subject of a patent obtained by Captain Blakely in February, 1855, and also of a patent taken by Mr. Longridge a few months later, soon after which time the late Mr. Brunel conceived the same idea, and, in ignorance of the existence of any patents on the subject, commissioned me to make for him a cannon upon this principle; but as soon as he discovered that the ground was occupied by patents he gave up the project, and for the same reason I abandoned it myself. Mr. Longridge has persistently advocated the use of wire for this purpose, and has more than once brought the subject before this institution. He has also suggested a form of gun designed with a view of obviating the objection of want of longitudinal strength, but I am not aware that his method of construction has been reduced to practice. Of the theoretical advantage of this system there can be no doubt, but the difficulties only begin when we endeavor to put the theory into practice, and no solution of the problem of how to do it can be accepted without the production and trial of an actual gun. My own attention was redirected to the subject nearly five years ago, when the patents had long expired; and, after making various preliminary trials with small wired cylinders, a 6-inch breech-loading gun of this construction was commenced in 1879, and finished in the beginning of the following year, since which it has undergone many severe trials. The charges used with it were large beyond precedent, and the energies developed proportionally high. Being satisfied with the results obtained with this gun, a second one of larger dimensions was commenced, and is now finished. Its caliber is 26 centimeters, or about 10¼ inches. Its length is 29 calibers, and its weight is 21 tons. In the previous gun I depended for end strength upon the thickness of barrel only, but in the new one layers of longitudinal ribbons are interposed between the coils in the proportion of one longitudinal layer to four circular layers. The longitudinals are secured to the trunnion ring at one end, and to a breech ring at the other, and are in themselves calculated as sufficient to resist the end strain on the breech independently of the strength afforded by the tube. The whole is encased in hoops shrunk upon the exterior of the coil, for the treble purpose of protection from injury, of preventing slipping in the event of the failure of an external strand, and of adding to the strength of the gun. This gun has already been tried and given results which, in relation to its weight, are unexampled except by its 6-inch predecessor. Various attempts have also been made abroad to reduce this system to practice, and it is understood that the French are at present engaged in making experimental guns upon the same general principle. With regard to the ribbon form of section, I prefer it to a square section of equal area, as being more favorable for bending over a cylinder; but any rectangular form is better than round wire on account of the flat bedding surfaces it affords.

The general features of the wire system are the building up from a steel tube, about one-half a caliber thick, a gun about a caliber in thickness of walls, by wrapping around a tube ribboned wire, or rather wire of a rectangular cross-section—under varying tension—for different distances from the axis of the bore, the ribbons being applied longitudinally as well as circumferentially; the wire being covered with hoops of steel or wrought iron of varying lengths, yet comparatively short, adding a protection to the wire, finish to the gun, and so locked in with the body underneath as to give increased longitudinal strength. Its gengeneral mode of construction, and the machinery employed for producing these guns, can best be brought to the attention of the department by the subjoined copy of letters patent granted to Sir William Armstrong, under date of December 28, 1880, and June 27, 1881, and the appended plates.

A. D. 1880, *28th December. No.* 5446.—*Ordnance, &c.*

LETTERS PATENT TO SIR WILLIAM GEORGE ARMSTRONG, OF ELSWICK WORKS, NEWCASTLE-UPON-TYNE, KNIGHT C. B., FOR AN INVENTION OF "IMPROVEMENT IN ORDNANCE, AND IN APPARATUS TO BE USED IN THE CONSTRUCTION OF ORDNANCE."

Provisional specification left by the said Sir William George Armstrong at the office of the Commissioner of Patents on the 28th of December, 1880.

Sir William George Armstrong, of Elswick Works, Newcastle-upon-Tyne, Knight C. B. Improvement in ordnance, and in apparatus to be used in the construction of ordnance.

This invention has for its object improvement in ordnance, and in apparatus to be used in the construction of ordnance, and relates to that class of ordnance in which strength is obtained by coiling wire upon a tube or cylinder under definite tension.

I will proceed to describe the apparatus which I employ in coiling wire upon the tube or cylinder.

The wire to be used for this purpose is reeled upon a pair of drums mounted in a frame which slides by the action of a leading screw in a direction parallel to the tube or cylinder on which the wire is to be coiled. Only one of these drums is used at once, the other being left at liberty for receiving a fresh supply of wire ready for application when the wire on the other drum has been wound off. At the commencement of the process the outer end of the reel of wire is made fast to the tube upon which the wire is to be wrapped, and which tube is rotated in a lathe or other similar machine, by which means the wire is drawn off the drum and coiled spirally upon the tube. The frame containing the drums is traveled at such a rate as will lead the wire on in a close spiral, and the varying speed which is required for this purpose may be effected by any of the ordinary feed motions in screw-cutting lathes, or other lathes, or in a more satisfactory manner by applying a small three-cylinder hydraulic engine to revolve the screw, the speed being regulated by varying the opening of the valve by which the water is admitted to the engine.

The degree of tension to be put upon the wire is controlled and regulated by the apparatus to be next described. Each drum in traveling with the frame slides upon a square shaft which revolves with the drum, but permits the drum to slide upon it the whole length of the travel. Upon one end of each shaft there is fixed a friction wheel to prevent the shaft from turning except under the resistance of the friction put upon the wheel by means of a band which surrounds it. This band has two levers attached, one of which is a mere arm projecting from it, and the other has a fulcrum upon one end of the band and pulls upon the other end by means of a short crank, as is usual in friction brakes, and by which means the band is tightened upon the wheel. These two levers are parallel to each other, or nearly so, the one for tightening the band being the upper one. When these levers are drawn together at the outer ends the friction band tightens, and when the ends are drawn apart the friction is relaxed. Suppose, then, these two levers to be projecting from the band rather below the horizontal position, and the upper one to be sufficiently weighted at the end to produce a friction on the wheel somewhat in excess of the equivalent tension to be put upon the wire; suppose, further, that the lower lever or arm be loaded with such a weight as will, when added to the weight on the tightening lever, and after taking into account the weight of the levers themselves, balance the required tension on the wire. Under these conditions when the wire is drawn off the drum the weight will be lifted, and would be carried round the circle were it not that provision is made to cause the levers to separate as they rise, and thereby lessen the friction, and as the same provision causes them to close as they fall, and thereby increase the friction, it is easy to see that they may be made to adjust themselves in the horizontal position, or within limits sufficiently near to it. This provision consists of a chain carried over a pulley fixed above the levers, and over another pulley fixed beneath them. One end of this chain is attached to the upper or tightening lever at any distance from the center of the wheel, and the other end of the chain, after passing over the lower pulley, is attached to the lower lever at a point a little more distant from the center than the other point of attachment. The slack of the chain is taken up by an adjusting screw or any other convenient arrangement. If the levers now rise the chain is taken up by the lower lever a little quicker than it is slacked off by the upper one, the difference being proportionate to the difference of radial distance of the two points of attachment from the center of the wheel. The result is that the levers are gently separated without materially affecting the aggregate load upon them, and thus the friction is reduced until it no longer exceeds the required tension on the wire. On the other hand, if the friction becomes too little to hold up the weights, the levers begin to descend, and in so doing the reverse action of the chain allows them to close, and thereby augments the friction until the tension and the friction again reach equilibrium.

Thus, by allowing the levers to range up and down a short distance above and below the horizontal line the wire can be wound off the drum with a practically uniform tension, and the amount of that tension can be regulated by the combined load on the levers.

It is not necessary to put any part of the weight upon the lower lever; but in that case the variation of the load due to the differential action of the chain will be at a maximum, and although it may not even then be sufficiently large to have any serious disturbing effect, it is better to divide the weight, and so reduce the disturbance as much as practicable.

To guard against a jerking action being set up by the elasticity of the levers and the changes from friction of rest to friction of motion, I apply a cataract cylinder and piston beneath each cylinder, to prevent its too-sudden descent at any moment. The same steadying effect may be obtained by using a "fly," which resists any sudden change of motion by fanning the air or any fluid in which it is immersed.

For the purpose of winding the wire upon each drum, hand gear is applied to enable the wire to be taken on while the other is paying off.

I use a three-cylinder hydraulic engine for rotating the tube on which the wire is coiled, because a more steady and adjustable action can be attained by such an engine than by the use of steam power, applied either separately and directly to the coiling machine, or through the medium of shafting used for driving other machinery as well.

The wire is of rectangular section, and it is coiled upon the tube or cylinder between shoulders, one at either end. The wire is secured to the shoulders at the commencement and at the end of each layer. For this purpose radial grooves are cut in the shoulders. The wire before commencing to coil is headed at the end, and the head is inserted into one of the radial grooves corresponding in form with the head. To secure the end of the wire on the completion of the layer, the wire as it lies upon the cylinder is bent or bulged out so as to make it enter a groove (of another form) in the shoulder. The bending is effected by the insertion of a tapered tool between the last convolution of the wire and that which immediately precedes it. The groove in the shoulder is of such a form as to be filled by the bulge in the wire thus produced. Several tools may be employed in succession to force the wire home into the groove, and then a small filling piece is inserted into the cavity produced between the two adjacent convolutions of the wire. Tapered filling pieces, passing around the cylinder, are laid against the shoulder, both at the commencement and the ending of the coiling of each layer of wire. These filling pieces occupy the spaces which would otherwise be left vacant between the coils and the shoulders. Over the coiled wire a jacketing tube, in one or several pieces, is applied, and is made to add to the longitudinal strength of the barrel through the intervention of a hoop fixed upon the breech end of the barrel beyond the base of the bore. This hoop may be notched or hooked upon the barrel in the usual manner where end hold is to be given; and the jacketing cylinder may be similarly attached to the exterior circumference of the hoop, or the attachment may in both cases be effected by the method hereinafter described.

Where the necessary longitudinal strength cannot be obtained without making the barrel of objectionable thickness, I either make up the deficiency by shrinking upon the barrel an additional cylinder, above which the wire coils are applied, or I interpose between any two layers of spiral wire, or above or below them all, a layer or layers of longitudinal wires or rods, which are held against end strain by the friction due to the pressure of the superposed material in tension, and where the superposed material is deficient in thickness for that purpose, I head the ends of the wires, so that they may take hold of a hoop firmly attached to the barrel.

In order to obtain where needed a more effectual longitudinal connection between an enveloping cylinder and the barrel or cylinder it incloses than is afforded by the usual method of notching and hooking, I slightly reduce in diameter the end of the barrel or inclosed cylinder for a few inches in length, and screw the reduced surface. I also screw the enveloping cylinder for a similar length at the same end, so that when it is shrunk upon the barrel an annular cavity is left between the two screwed surfaces. Into this cavity I pour melted phosphor bronze or other suitable metal, which is thus molded into the form of an interlocking screw.

Specification in pursuance of the conditions of the letters patent filed by the said Sir William George Armstrong, in the Great Seal Patent Office, on the 27th June, 1881.

Sir William George Armstrong, of Elswick Works, Newcastle-upon-Tyne, Knight C. B. "Improvements in ordnance and in apparatus to be used in the construction of ordnance."

This invention has for its object improvements in ordnance and in apparatus to be used in the construction of ordnance, and relates to that class of ordnance in which strength is obtained by coiling wire upon a tube or cylinder under definite tension.

In using the term "wire" in this specification, I mean steel, or iron, or other ductile metal reduced by drawing, rolling, or otherwise, to a sufficiently attenuated section for wrapping, in the cold state, upon a gun cylinder, and I do not confine the term to any particular form of section.

I will proceed to describe the apparatus which I employ in coiling wire upon the tube or cylinder.

The wire to be used for this purpose is reeled upon a pair of drums mounted in a frame, which slides by the action of a leading screw in a direction parallel to the tube or cylinder on which the wire is to be coiled. Only one of these drums is used at once, the other being left at liberty for receiving a fresh supply of wire, ready for application when the wire on the other drum has been wound off. At the commencement of the process the outer end of the reel of wire is made fast to the tube upon which the wire is to be wrapped, and which tube is rotated in a lathe, or other similar machine, by which means the wire is drawn off the drum and coiled spirally upon the tube. The frame containing the drums is traveled at such a rate as will lead the wire on in a close spiral, and the varying speed which is required for this purpose may be affected by any of the ordinary feed motions in screw-cutting lathes, or other lathes, or in a more satisfactory manner by applying a small three-cylinder hydraulic engine to revolve the screw, the speed being regulated by varying the opening of the valve by which the water is admitted to the engine.

The degree of tension to be put upon the wire is controlled and regulated by the apparatus to be next described. Each drum traveling with the frame slides upon a square shaft which revolves with the drum, but permits the drum to slide upon it the whole length of the travel. Upon one end of each shaft there is fixed a friction wheel to prevent the shaft from turning, except under the resistance of the friction put upon the wheel by means of a band which surrounds it. This band has two levers attached, one of which is a mere arm projecting from it, and the other has a fulcrum upon one end of the band, and pulls upon the other end by means of a short crank, as is usual in friction brakes, and by which means the band is tightened upon the wheel. These two levers are parallel to each other, or nearly so, the one for tightening the band being the upper one. When these levers are drawn together at the outward ends the friction band tightens, and when the ends are drawn apart the friction is released. Suppose, then, these two levers to be projecting from the band rather below the horizontal position, and the upper one to be sufficiently weighted at the end to produce a friction on the wheel somewhat in excess of the equivalent tension to be put upon the wire; suppose, further, that the lower lever or arm be loaded with such a weight as will, when added to the weight on the tightening lever, and after taking into account the weight of the levers themselves, balance the required tension on the wire. Under these conditions, when the wire is drawn off the drum the weight will be lifted, and would be carried round the circle were it not that provision is made to cause the levers to separate as they rise, and thereby lessen the friction; and, as the same provision causes them to close as they fall, and thereby increase the friction, it is easy to see that they may be made to adjust themselves in the horizontal position, or within limits sufficiently near to it. This provision consists of a chain carried over a pulley fixed above the levers, and over another pulley fixed beneath them. One end of this chain is attached to the upper or tightening lever, at any distance from the center of the wheel, and the other end of the chain, after passing over the lower pulley, is attached to the lower lever at a point a little more distant from the center than the other point of attachment. The slack of the chain is taken up by an adjusting screw or any other convenient arrangement. If the levers now rise the chain is taken up by the lower lever a little quicker than it is slacked off by the upper one, the difference being proportionate to the difference of radial distance of the two points of attachment from the center of the wheel. The result is that the levers are gently separated without materially affecting the aggregate load upon them, and thus the friction is reduced until it no longer exceeds the required tension on the wire. On the other hand, if the friction becomes too little to hold up the weights the levers begin to descend, and, in so doing, the reverse action of the chain allows them to close, and thereby augments the friction until the tension and the friction again reach equilibrium.

Thus by allowing the levers to range up and down a short distance above and below the horizontal line, the wire can be wound off the drum with a practically uniform tension, and the amount of that tension can be regulated by the combined load on the levers. It is not necessary to put any part of the weight upon the lower lever; but in that case, the variation of the load due to the differential action of the chain will be at a maximum, and although it may not even then be sufficiently large to have any serious disturbing effect, it is better to divide the weight, and so reduce the disturbance, as much as practicable. Although a chain attached to the levers at different radial distances, and passing over pulleys, is a very simple and effective method of producing the closing and separating action of the levers, yet it is not a necessary feature in the arrangement, as the same effect may be produced on the levers by other appliances.

To guard against a jerking action being set up by the elasticity of the levers, and the changes from friction of rest to friction of motion, I apply a cataract cylinder and piston beneath each lever, to prevent its too sudden descent at any moment. The same steadying effect may be attained by using a "fly," which resists any sudden change of motion by fanning the air or any fluid in which it is immersed.

For the purpose of winding the wire upon each drum, hand gear is applied to enable the wire to be taken on while the other is paying off.

I use a three-cylinder hydraulic engine for rotating the tube on which the wire is coiled, because a more steady and adjustable action can be attained by such an engine than by the use of steam power, applied either separately and directly to the coiling machine, or through the medium of shafting used for driving other machinery as well.

I prefer wire of a rectangular section, and it is coiled upon the tube or cylinder between shoulders, one at either end. The wire is secured to the shoulders at the commencement and at the end of each layer, or if wire of sufficient length be used, it may be coiled to and fro, so that more than one layer may be completed before the terminating fastening be made. For this purpose radial grooves are cut in the shoulders. The wire, before commencing to coil, is gibbed or headed at the end, and the head is inserted into one of the radial grooves corresponding in form with the head. To secure the end of the wire on the completion of the layer, the wire as it lies upon the cylinder is bent or bulged out so as to make it enter a groove (of another form) in the shoulder. The bending is effected by the insertion of a tapered tool between the last convolution of the wire and that which immediately precedes it. The groove in the shoulder is of such a form as to be filled by the bulge in the wire thus produced. Several tools may be employed in succession to force the wire home into the groove, and then a small filling piece is inserted into the cavity produced between the two adjacent convolutions of the wire. Tapered filling pieces, passing around the cylinder are laid against the shoulder, both at the commencement and the ending of the coiling of each layer of wire. These filling pieces occupy the spaces which would otherwise be left vacant between the coils and the shoulders. Over the coiled wire a jacketing tube, in one or several pieces, is applied, and is made to add to the longitudinal strength of the barrel, through the intervention of a hoop fixed upon the breech end of the barrel beyond the base of the bore. This hoop may be notched or hooked upon the barrel in the usual manner where end hold is to be given, and the jacketing cylinder may be similarly attached to the exterior circumference of the hoop, or the a tachment may in both cases be effected by the methods hereinafter described.

Where the necessary longitudinal strength cannot be obtained without making the barrel of objectionable thickness, I either make up the deficiency by shrinking upon the barrel an additional cylinder, above which the wire coils are applied, or I interpose between any two layers of spiral wire, or above or below them all, a layer or layers of longitudinal wires or rods, which are held against end strain by the friction due to the pressure of the superposed material in tension, and where the superposed material is deficient in holding power for that purpose, as it generally will be towards the ends of the cylinder to which the longitudinal wires are applied, I head the ends of the wire and notch them into a hoop firmly attached to the cylinder at each end of the coil. An additional advantage obtained by this arrangement is that the wire may be put on hot and allowed to contract so as to produce a state of initial tension, which increases their efficiency for longitudinal support.

In order to obtain, where needed, a more effectual longitudinal connection between an enveloping cylinder and the barrel or cylinder it incloses than is afforded by the usual method of notching and hooking, I slightly reduce in diameter the end of the barrel or inclosed cylinder for a few inches in length and groove the reduced surface, either spirally or concentrically. I also groove the enveloping cylinder in the same manner for a similar length at the same end, so that when it is shrunk upon the barrel, an annular cavity is left between the two screwed or grooved surfaces. Into this cavity I pour melted phosphor bronze, or other suitable metal, which is thus molded into the grooves like an interlocking screw. I also effect the same object by serrating the surfaces to be held against slipping and interposing a thin sheet of copper. The outer cylinder being then shrunk upon the copper, squeezes the copper into the serrations and so interlocks the two cylinders.

In order that my said invention may be most fully understood and readily carried into effect, I will proceed to describe the drawings hereunto annexed.

Description of the drawings.

Fig. 1 (Plate XII) is a side elevation of the mechanism for winding the wire on to the tube or gun. Fig. 2 (Plate XIII) is a plan of the same. Fig. 3 (Plate XIV), an end elevation, showing the hydraulic engine for traversing the drum laterally at a variable speed under the control of the operator, so that the wire unwinding may lead truly onto the tubes or gun. Fig. 4 (Plate XIV) is a section of the machine on the line S S in Fig. 1 (Plate XII).

In the above figures, A A are the paying-off drums. B B is the frame containing the drums, and which is traveled longitudinally in either direction by the operator of the hydraulic engine and under control of the operator. C is the leading screw, which travels the frame, and D is the hydraulic engine, which revolves the screw. Each drum slides upon a square shaft, E, which revolves with the drum. F F are the friction wheels fixed at one end of each square shaft. G is a lever, which tightens the friction band on each wheel. H is the lever which projects as an arm from the friction band, to which it is attached at the two points *h h*. I I are the weight cases for loading the tightening lever G, and J J are the weight cases for loading the projecting arms H H. Each pair of levers is connected by a chain or cord, K K, which is fastened to the tightening lever G at a point, k^1, and, after passing over a pulley, L, above, and then over another, L^1, below, is made fast to the lower lever or projecting arm H at a point, k^2, at a little greater radial distance from the center of the friction wheel than the point k^1. The tension on the wire is regulated by the joint load on the levers, which are prevented from lifting their loads to an inconvenient height by the action of the chain or cord which, by pulling downwards on the lower lever and upwards on the upper one, relieves the friction on the band during the ascent of the weight without materially affecting the resistance due to the aggregate load on the levers. M M are the cataract cylinders for steadying the motion of the levers. N N is an ordinary winch arrangement which can be thrown into gear with either square shaft, leaving the other one free, which serves for coiling wire upon one drum while the wire on the other drum is being wound off upon the gun. O is a reversing handle for changing the direction of the frame, and which, as shown in the drawing, is effected by clutch wheels, but may equally well be effected by reversing the rotation of the feed engine. P is the starting and stopping lever of the hydraulic engine. Q is a portion of one of the pair of standards between which the tube or gun is carried in a horizontal position, and rotated by a hydraulic engine, which is not shown in the drawings.

Fig. 5 (Plate XI) is a longitudinal section through an enveloping cylinder of coiled wire, A, containing four layers of longitudinal wires, each marked B; it also shows a similar section of a portion of a lower coiled wire cylinder, C, which does not contain any layers of longitudinal wires. D^1, D^2, and D^3 are the hoops to which the ends of the wires are made fast. The heads of the longitudinal wires and the circular grooves in which they are inserted are marked E. The cylinder on which the wire is coiled is shown at F, and the outer hoops or casing of the wire are marked G.

Fig. 6 (Plate XI) is an enlarged view of one end of Figure 5, and shows each separate wire in section.

Fig. 7 (Plate XI) shows a side elevation or a plan of a portion of the tube or gun, and represents the mode of fastening the ends of the coiled wire. At the starting end of the coil the wire is formed into a gib of the shape shown at A, and is inserted into a radial groove of a corresponding form in the hoop to which the attachment is to be made. The depth of this radial groove may be sufficient to receive any number of wires. In Figure 6 the depth of these grooves is shown by dotted vertical lines at the places marked A in that figure. The finishing end of the coil is fastened by bending the wire sideways, as shown at B, into a radial groove of corresponding form. The bending is effected by a series of wedge-like tools inserted one after the other, and the end is finally secured by a wedge or filling piece, C. D D are inclined or tapered pieces laid in against the hoop to fill in between the coil and the hoop on the tube or gun.

Fig. 8 (Plate XI) is a section showing the mode of fixing an outer cylinder upon an inner one so as to resist the tendency to slide longitudinally. A A are two grooved or screwed surfaces, the one on the outer and the other on the inner cylinder. Between these surfaces there is an annular space, B, to be filled with fused phosphor bronze or other suitable metal. The fused metal becomes molded into the grooves on either side and thus locks the two cylinders together.

Fig. 9 (Plate XI) is a section showing another modification of the method of preventing one cylinder sliding lengthways over another. In this case the surfaces of the cylinders are slightly serrated, as shown at A A, and a thin sheet of copper, or other compressible metal, is bent round the inner cylinder. The outer one is then shrunk upon the copper, which becomes embedded in the serrations and so interlocks the surfaces. This method may be applied either at the ends of the cylinders, or at any intermediate part, or over the whole length.

Having thus described the nature of my said invention, and the manner of performing the same, I would have it understood that I claim—

First. The arrangement of the paying-off drum in such manner that it can be traversed laterally with a variable feed motion, so that as the wire is unwound from the drum it may be laid on to the tube or gun in a close spiral, substantially as described.

Second. The method of regulating the tension upon the wire by means of a friction wheel and weighted levers, which, by a differential action, substantially as described, maintain a nearly uniform tension on the wire, the amount of which is regulated by the load upon the levers.

Third. The combination, with such frictional apparatus, of controlling mechanism, substantially as described, to prevent sudden variation in position and a jerking action in the levers.

Fourth. The method, substantially as described, of securing the wire at the starting end by means of a gib or bent head inserted in a radial groove.

Fifth. The method, substantially as described, of fastening the wire at the terminating end of the coil, by bulging and wedging it into a groove of corresponding form.

Sixth. The application of layers of wire laid longitudinally to give end strength to the gun, and the method of securing the ends of the longitudinal wires by heading and notching, in the manner described.

Seventh. The method of increasing the longitudinal hold of an outer cylinder upon an inner one, by introducing another metal into a grooved annular recess, which metal, adapting itself to the form of the recess, locks the two cylinders together substantially as described.

In witness whereof, I, the said Sir William George Armstrong, have hereunto set my hand and seal this seventeenth day of June, in the year of our Lord one thousand eight hundred and eighty-one.

W. G. ARMSTRONG. [L. S.]

The details of building up these guns, taking the 10.236-inch (see Plate VI) as a type, it appears are as follows:

The steel tube constituting the body of the gun, after being turned to the dimensions shown in the drawing (Plate XI, Fig. 5), is next provided with the different pieces affording shoulders, between which the forward sections of wire are wound or laid on. These rings being shrunk on, and having serrations corresponding to the ones on the tube, an intervening thin copper band, by its compression under shrinkage, locks them to the tube.

The rear band (see A, Plate XI) is also similarly attached to the tube. The tube, being then made ready for the reception of the wire, is properly centered in the coiling lathe (see description in patent specifications), and the different sections between the shoulders of the ring, except the rear section, have the ribband steel applied, both circumferentially and under different tensions and longitudinally (see Fig. 5, Plate XI).

The trunnion ring must be next shrunk on over the wire and part of the adjacent rings. The winding and laying on of the rear section of ribband completes the wiring of the gun, at the breech twenty layers being placed around the body and four layers lengthwise of the bore. The different sections of wrought-iron hoops to complete the structure are laid on in succession and in turn, and the piece completed as far as the building up is concerned.

The weights of the different parts, as approximately calculated, are as follows:

	Tons.
Tube (steel, Whitworth's fluid-compressed)	7.28
Steel ribband	5.93
Wrought-iron parts	7.79
Total	21.00

The 13-inch 44-ton gun of this type is somewhat different in its details of construction, as will be found on examination of Plate V. The gun is designed without trunnions. Four square-cut rings on the under section of the hoop, corresponding to the trunnion band, are seated in a block grooved for their reception, and attached to the carriage.

All steel and wire are used in rear up to this equivalent of the trunnion hoop, the exterior portion for this band, however, being made of wrought-iron sections.

Another feature is that a steel jacket is shrunk over the inner tube, enveloping it to a distance a little beyond the chamber, and is believed to be serrated on its interior, and united longitudinally to the inner tube with corresponding serrations by melted phosphor bronze or thin copper tube. No longitudinal wires are used. In general subdivision of parts it otherwise resembles its prototype, the 10.236-inch.

This gun is expected to reach the enormous muzzle energy of 27,500 foot tons, or, say, 622 foot-tons per ton of metal of weight of gun. The United States projected breech-loading gun of 55 tons could only realize, say, 20,000 foot-tons muzzle energy, or, say, 350 foot-tons per ton of metal of the weight of the gun.

The recent firings with one of the 10.286-inch guns are tabulated below:

Number of rounds.	Weight of charge.	Weight of shot.	Velocity.	Pressure.	Energy per ton of metal in gun.	Energy.
	Lbs.	*Lbs.*	*Feet.*	*Lbs.*		
15	300	400	2,238	....	....	....
15	300	500	2,150	67,000	760	16,000

The date of firing was recent, and the pressure and foot-tons of energy attained at the muzzle, also foot-tons of energy per ton of weight of the gun, are the figures furnished me by Captain Noble of the Elswick Works.

The 43-ton breech-loading gun, ordinary Armstrong type, has a service charge (as we have seen above) of 330 pounds, with a 700-pound projectile, and a resulting muzzle velocity of 1,845 feet (see table), and hence yielding, say, a muzzle energy of about 16,500 foot-tons. A wire gun of 21 tons gives about the same power, but, being impressed upon a smaller area of surface, its penetrating power is greater.

It would be inferred from these figures that even constructions wholly of steel, otherwise than those using wire, are not trusted—by constructors who have had experience in both—to attain anything like the power expected from the use of the latter.

Referring to views stated above,* advocating the introduction of an auxiliary thin steel oil-tempered lining tube as probably affording an improvement, or as at least embodying an idea worthy of consideration, I herewith append (see Plate VII) a drawing introducing this feature of construction in a wire gun.*

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* See page 226.

In closing these remarks regarding this recent novelty—the introduction of wire guns, after the peculiar pattern as presented to the ordnance constructors of the civilized world by the Elswick Works—I have to state my positive conviction, taking cognizance of the fact that, although in a measure experimental, the wire system has yet been so far advanced up to date by actual experiment and tests—and tests so satisfactory as to lead rapidly to constructions of the highest nature—both in England and France, that this mode of building up heavy ordnance should, from palpable reasons independent of its strength, rank high, if not first, in the experimental essays to be made in the United States to solve the problem of heavy ordnance, not only in the attainment of powerful but light armament, but also in the securement of a mode of construction which can most readily and quickly be developed by the manufacturing interests of our country.

The incalculable advantages which arise in built-up systems, in contradistinction to plans involving the use of huge homogeneous masses (like cast iron), of a subdivision into parts comparatively light in weight, and hence readily produced and easily handled, are carried out in the highest degree in the system under consideration.

This subdivision admits of opportunities for accurate inspection, the attainment of a minute and thorough knowledge of the physical properties of the metals employed in the building up of our structures, and enables us to apply more thoroughly the sound and well-established modern theories of gun construction. The germ of these theories is to be found in the developments of General Rodman in his experiments, which, independent of the inferior metals at his command, enabled him to point out the great general principles which should underlie all sound constructions—the principles of initial tension and varying elasticities.

If we take the 10.236-inch Armstrong wire gun as an illustration, we will find that the heaviest part to be handled—the internal tube—only weighs about 7.28 tons. The wire is, of course, of no moment as to weight to be handled, and the superimposed frettes are none of them so heavy as to require especial consideration of the question of ease in handling. Other natures of higher power will, as seen in the 13-inch (the heaviest weight employed in it not exceeeding 12 tons), likewise confirm the advantages of the introduction of the subdivision of parts found in the system.

The simplicity of plant required is apparent, especially when we consider that the steel interests of the country should, if not now, yet in the near future, produce the tubes, wire, frettes, &c., and that the assembling and finish can be done in any well-appointed machine-shop, well provided with the necessary lathes for turning, boring, and wind-

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*In this plan it will be seen that the steel jacket in which the fermeture finds its bed is locked to the trunnion block *and at the front*, a projecting ring being left on the jacket, which ring bears against the front surface (see plate) of the trunnion band. Additional longitudinal strength is obtained by uniting the jacket with the interior tube by phosphor bronze poured into the annular cavity (serrated walls) between the two pieces, after the plan of Sir William Armstrong. This also prevents the tendency of the interior tube to move to the front under the thrust of the projectile, and the powder-gas pressure at the throat of the chamber. No details are determined upon, the sketch only presenting the *general features* of a construction for general consideration. It is presented without any recommendation.

The gun should not exceed in weight 40 tons.

ing the wire; also rifling machines, and other and simpler tools for finishing and fitting minor parts.

This last feature, arising from the construction, leads me to point out that, without interference with the private manufacturing interests of the United States, some of our present arsenals—such as Frankford and Springfield—have ample facilities for the production of *experimental* guns on the plan under consideration, and, upon the above condition of supply of parts, even of the highest calibers required for armament. Heretofore this has been impracticable, as the expensive, cumbersome, and large plant in huge pits and furnaces and heavy cranes and lathes necessary to produce huge homogeneous masses, has not been at our command. The system now under discussion, however, dispenses in a great measure with all these, and brings the construction within the scope of ordinary appliances and ordinary machinery, and would, in the event of a decision to try it, lead—if the trials were successful—to a bringing into play our present resources for experimental constructions, to afford models and experience for fabrication by the contractors to be intrusted with the work of construction.

The benefit to be secured by enabling us to provide standards for fabrication is, in my judgment, incalculable; but, of course, this advantage can only be urged in the cases where it can be attained in connection with the most advanced and best construction, to which it must always, of course, remain *subordinate*.

The time required for the construction of these guns in quantity must necessarily be less than for the less subdivided types, provided the facilities for the production of the different parts are fully developed and available; and this important element is one not to be overlooked in studying out the problem of the best and most readily available rifled ordnance to supplant our present smooth-bore guns.

No accurate data are, as yet, at hand as to comparative cost of this system with the ordinary built-up steel ones; but it is not seen that any wide differences in favor of the solid jackets over built-up wire sections can possibly exist. It is stated that a 100-ton Armstrong gun (ordinary type) costs about $80,000; and an 80-ton Woolwich gun about $50,000; and that a 100-ton wire gun, after the plan of Longridge, would only cost $40,000. It is hardly probable, however, that wire guns can be produced at so much less price than the built-up steel or steel and wrought-iron models; but even if they cannot be made for less than, say, $625 per ton—the Woolwich figures—a comparatively inexpensive gun would be the result.

Sixty-ton 12-inch cast-iron guns lined with steel tubes and fretted externally would, it is fully believed, even made in quantities, exceed in cost per gun those of *equal power* made with wire. It is doubtful, from present prices (here) for the former guns, if such ordnance could be produced for less than $50,000 apiece, or, say, over $800 per ton, and under the most favorable circumstances of prices for labor and material.

In closing these remarks on steel ribband guns in England, attention is invited to the change in details of construction in the latest model—the 13-inch. The most important departure in the construction from its prototype, the 10.236-inch, is the introduction of an auxiliary steel jacket shrunk over the inner tube, and in all probability (see specification) united to it by serrated surfaces, between which copper sheets or phosphor bronze finds place, and undoubtedly introduced to secure additional longitudinal strength. This diminishes the quantity of wire, but gives additional longitudinal strength. A deficiency in this respect seems to be a source of anxiety, influenced probably from the failure of the gun on board of the "Duilio." An ample provision for it, it would seem, is intended in this last structure to be made, sacrificing to a limited extent, however, the presumed advantage of wire over solid rings or frettes. This, it is deemed, can be readily afforded, as there seems to be no misgivings as to the tangential strength of the system being all, and more than all, that would be demanded in proof or service.

A different plan for securing longitudinal strength will be alluded to when the Schultz system of construction is reached in this report.

The inherent weakness in regard to the longitudinal stress in the system leads me further to remark that it becomes a matter of the very first importance, in considering plans based upon it, to scrutinize closely the features which are designed to provide for this strain.

The Armstrong, the Schultz, and probably others which may be presented to the government, all will undoubtedly meet the requirements in providing against tangential rupture; but it will be a matter for close study to select for test, if wire should be deemed worthy of trial, those which promise best in securing a system, if not relatively as strong longitudinally as tangentially, yet so far providing for the former stress as to place beyond a shadow of doubt (as far as human judgment can provide) their capacity for endurance in this respect.

The tendency in built up constructions, under violent vibrations, brought into existance by discharge and aggravated by repeated firings with heavy charges, to separate piece from piece, and the effects arising from the tendency of the parts to leave each other by the different inertias of their different masses, both combine to render the problem in this gun construction one of peculiar difficulty, and demanding the closest calculations and deep and prolonged study. The very *jars* may in an indifferent construction be sufficient, if not to part the gun, at least to render it unsafe for the repeated discharges contemplated for actual service.

WHITWORTH'S GUNS.

Sir Joseph Whitworth & Co., in presenting for exhibition in Paris, in 1878, the products of their works in Manchester, make the following general remarks regarding their steel, to wit:

> The Whitworth fluid-pressed steel, from which the following objects are made, is submitted to great pressure whilst in the fluid state. By this means perfect soundness and homogeneity, even in the largest masses, are obtained; it is afterwards forged to the required shape by hydraulic pressure.
>
> The distinguishing characteristics of the Whitworth fluid-pressed steel are soundness, strength, and ductility. It is made of various tempers to suit all purposes, and is specially suited for purposes where it is exposed to sudden and violent strains.

It is only the intention to allude here to Whitworth's guns and his idea of gun construction, leaving the question of his mode of production of steel for consideration under the heading of steel and other material for gun building.

The firm stated in 1878 that—

> The Whitworth system of breech loading has been very severely tested with most satisfactory results. Two guns, viz, a 7-inch, firing projectiles weighing 150 pounds, and a 9-pounder, have been tried by the English Government with very satisfactory results. The ease with which the breech arrangement worked throughout the experiments was very remarkable.
>
> The Brazilian Government have adopted the Whitworth ordnance, in consequence of the satisfactory results they had had with it during the Paraguayan war. Many of the guns fired from 4,000 to 5,000 rounds without being damaged.

The following description of his 9-pounder breech loading gun, which embodies the general features of his plan, and the accompanying plate, No. VIII, are submitted as interesting; attention only, however, being especially invited to the mode of closing the breech.

> The breech-closing arrangement of the gun consists of a breech-block sliding horizontally in grooves inclined at an angle to the rear face of the gun, the block being moved by means of a tappet handle which revolves a pinion-gearing into a rack on the gun; the block is held in its place, when closed, by a catch.
>
> The rifling is polygonal, being a hexagon with rounded corners. The powder-chamber is enlarged in diameter in order to burn an increased charge. There is also a slightly-enlarged shot-chamber, to insure ease in loading.
>
> The powder-charge is contained in an ordinary serge-bag, no metallic case being employed.
>
> All escape of gas is prevented by an elastic steel ring in the rear of the gun, and a disc in the face of the breech-block, which are pressed tightly together when the block is closed. This ring and disc are movable and can be readily replaced.
>
> Owing to the simple form of the rifling, the projectiles for all the Whitworth guns are molded by self-acting machinery, and fired as they are cast without being planed. By this means there is a saving in first cost, and, as there is no soft metal required to give rotation, the projectiles, when recovered after practice, can be fired several times.

This gun has withstood the severest tests—among others, those in which elongated projectiles of lead of 10 pounds and 3 pounds of powder were used.

The mode of closing the breech has all the simplicity of the Krupp, and the fermeture can be manipulated with such ease and rapidity as to lead to the belief that, for field service especially, it would prove superior to both the interrupted screw and the sliding-block systems.

The views of the Manchester Works are that "steel and steel alone" should be used for the construction of guns; "field guns forged solid, and afterwards bored and rifled, the trunnion hoop being screwed on; and that for larger guns the barrel should be forged hollow, the strength and weight being obtained by adding hoops according to the size of the gun."

Alluding to some experiments made at the Manchester Works, it is stated—

> The tubes are of fluid-compressed steel, and have been subjected to explosions of gunpowder. The large tube, 26 inches long, 7.83 diameter, with 2.56 bore, being that of a 9-pounder field gun. It has had 48 explosions with 1½ pounds of powder. The strain on the metal is about six times greater when the ends are closed than when a gun is fired in the ordinary way. The force of the explosion being so great, a small permanent alteration took place at the first explosion, and the expansion of the bore has been going on every time it has been fired, and now amounts to nearly 0.2 of an inch. The tube was never expected to stand such a number of explosions. Seventy-two pounds of powder have now been fired in it. A cast-iron tube of the same dimensions burst at the first explosion with 3 ounces of powder.

No comparisons are made between this steel and other well-known varieties; but attention is invited to the fact that a cast-iron cylinder of the same dimensions burst at the first round, with only one-eighth of the charge employed with the compressed steel. The tenacity of the cast iron is not stated, but as the metal—Sir Joseph Whitworth says—was known to be of good quality, it is fair to presume that it was of the ordinary grade of English cast iron for guns, the tensile strength of which is given by English authorities as ranging from 20,000 to 31,000 pounds per square inch. The great enlargement (0.2 inch) resulting from the repeated firings of the steel cylinder is worthy of note, as showing the capacity in toughness and ductility of steel produced by the Manchester processes.

The following general remarks regarding gun construction, made by Sir Joseph Whitworth, may be of interest as embodying views and facts which have a prominent bearing on the gun problem of to-day:

> It may be mentioned that when rifled guns were first adopted in the service they were breech loaders; but their construction, and the comparatively weak wrought

iron of which they were made, only allowed in the 7-inch-bore gun, 4 tons weight, a charge of 14 pounds of powder, and the shot was two diameters long, weighing 110 pounds. Such being the state of things at that time, I made a 7-inch-bore muzzle-loading gun, 7 tons weight, charge of powder 22 pounds, and a shot three diameters long, weighing 150 pounds.

This gun was consequently far more powerful than the service breech-loading gun of the same bore, and the War Department had other muzzle-loading guns made of the same proportions as regards weight and bore.

When fluid-compressed steel proved so completely master of gunpowder, the writer at once saw that more powder might be fired from a breech-loader with a large powder-chamber than could be consumed in a muzzle-loading gun. Our 7-inch breech-loader fires 33 pounds of powder, being more than double the charge that is fired from the service breech-loader.

The following are some of the results obtained from the writer's breech-loading guns, as regards elevation and range, low trajectory, and penetration.

At Southport, in October, 1872, with the 9-pounder at one degree elevation, the range was 1,018 yards. The present service muzzle-loading gun at two degrees (being double the elevation) has a range only of 1,065 yards.

A specimen exhibited shows the wonderful penetration of the field gun, 3-inch bore, the armor-plate pierced being 4½ inches thick. In comparison with this result, in the trials made at Shoeburyness with the service 7-inch breech-loading gun and the 96-hundred weight cast-iron 68-pounder, experiments were carried on for about two years without being able to penetrate this thickness of armor-plate.

It was in October, 1858, that the writer first penetrated 4½ inch armor with solid shot; and on the 16th of September, 1872, he first penetrated, at Shoeburyness, an armor-plate with a steel shell, much to the surprise and astonishment of all the military men who witnessed it.

Guns of enormous size are now being made at Woolwich at an enormous expenditure. These guns must needs be powerful on account of their great weight and size; but the writer maintains that this enormous size is unnecessary. But if monster guns were wanted, they could be made at far less cost by means of the Siemens-Martin furnace and fluid compression. Supposing a hoop was wanted, say, 20 tons weight, the time required for its production by this process would not, commencing with the raw material, he believes, be more than one-tenth the time required by the forging, coiling, and welding processes. Again, as regards quality of material, good iron was given up being used at Woolwich some time ago, as it was found that weak, poor iron was easier to weld and work than good iron.

It is just the contrary with the Siemens-Martin or the Bessemer processes, everything being in favor of using good material; and the writer wishing to convince the Admiralty and War Department of the superiority of his steel guns, particularly of the breech-loader, offered to lend them a 7-inch breech-loading gun, firing 33 pounds of powder, and also a 35-ton muzzle-loading gun, which fires an armor-piercing projectile five diameters long, 1,250 pounds weight, with a bursting charge of 58 pounds. Both these offers were declined, much to the surprise of the Brazilian authorities, from whom permission had been obtained to lend these two guns.

The day of trial may be postponed by the making of enormous guns which astonish and mislead the public, but it would be far better for an immediate trial to be made with the best guns of moderate size that can be produced. With strong, ductile, sound steel the breech-loading gun, with its large powder-chamber, whatever be the size, must be superior to the muzzle-loader.

To prevent being misunderstood with reference to the weight of guns in relation to their bore, it may be stated that the writer has, for ship guns particularly, advocated greater weight for a given size of bore.

The first 12-inch-bore guns made at Woolwich were 23 tons weight, afterward increased to 25 tons.

In 1869 the writer submitted to the Admiralty a design for a 12-inch-bore gun of fluid-compressed steel, and he specified that the weight of the gun must be 35 tons, for he had always considered that (except for a mountain gun) there should be 105 pounds weight of gun for every pound of shot of 3 diameters long.

It was, however, determined by a committee at the War Office that the gun should be made at Woolwich; and the writer's weight for that size of bore was taken, and has been adopted ever since.

With weak materials, weak powder, long guns, and short projectiles must be used.

Strong, ductile, sound material allows of strong, quick-burning powder, short guns, long projectiles, and rapid rotation.

A further allusion to the war material and other productions of the Manchester Works will be made under the heading of "Whitworth steel."

The attention of the department has been called in the above remarks to all of the more prominent systems of gun constructions in England, and it is only necessary in closing them to make a short resumé of the most salient features in the state of the art of building heavy ordnance in that country.

It will be observed that built-up gun constructions are alone considered as affording a reasonable solution of the problem; that steel tubes, in combination with wrought iron or steel, constitute the prominent types; that breech-loading systems, using the interrupted screw or French pattern, are rapidly superseding muzzle-loading guns; and, finally, the more advanced opinions lead strongly to the belief that the true direction in which progress is to be made and light guns secured, combining great strength with high power, resulting from the use of large charges of powder and heavy projectiles, and in bores ranging from 26 to 30 calibers in length, is to introduce a greater degree of subdivision than found in the present systems by the use of steel wires superimposed on steel tubes, which in their turn are jacketed and finished externally by steel bands.

FRENCH HEAVY ORDNANCE.

(16 plates.)

NAVAL.

The sea-coast armament of France, as well as the arming of her fleets, is provided for under the control of the marine and colonial bureau; and the principal works where especially the cast-iron parts are made, and the assemblage of the different sections, steel or otherwise, entering into their built-up gun constructions are completed, and finished ordnance produced, are at Rouelle; the polygon of Gavre being the proving ground for testing the various experimental ordnance for the naval service.

In 1864, the constructions for the marine service received an impetus which has led to the more advanced development of the present day. The cast-iron constructions of that date were fretted and rifled; but few were breech-loaders, and their caliber did not rise above 16 centimeters.

From that date, productions ranging in weight from 3,000 to 4,000 kilograms were superseded by others increased to from 15,000 to 20,000 kilograms; and as the developments in steel were not sufficiently advanced to afford constructions purely from that material, the resources at the disposal of the French constructors were still confined to the use of cast iron in the bodies of their guns with superimposed frettes of puddled steel. This artillery since 1865 comprises calibers ranging from 5.51 inches up to 10.63 inches, or 27^{cm} (Plate XV), and were provided with single frettes for small calibers, and double frettes for larger ones, and were all breech-loaders. These guns, it is stated by Colonel Sebert, by the addition of frettes, had lost that dangerous feature found in the *pure cast-iron model* it superseded, of *rupturing without warning*, only save that slight indication of wearing out given by the enlargement of the vents.*

Although this system was regarded as affording at that time a reasonably powerful gun, with sufficient tangential strength for the moderate charges employed, yet no provision for increased longitudinal resistance found place, and for want of this transverse strength, "*déculassement*" *was the habitual mode of the destruction of the guns of the model of* 1864.

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* This confirms all modern experience with pure cast-iron constructions.

This, in general terms, shows that the experience of France has proved the longitudinal weakness of cast-iron constructions, and that it will not do to depend upon cast-iron seats for the fermetures, especially if anything like the powerful charges and heavy projectiles required in modern service should attain.

This inherent weakness led to the next step in progress on the basis of the model of 1864, and that was the introduction of short, steel, oil-tempered tubes, principally of Firth's manufacture, which are shrunk within the cast-iron bodies, and which, with increased thickness at the seat of the fermeture, affording a high-pitched, coarse, thick screw on the exterior, permitted the tubes being locked into the cast iron. They thus produced a gun whose broad features were a steel-fretted cast-iron body lined with a hammered crucible steel tube (oil tempered), extending about one-half of the length of the bore, and the result was what is known in France as the model of 1870.

It will be noticed that progress based upon a large experience, both by experiment and by actual service, led to the complete abandonment of pure cast-iron constructions as too defective even to be trusted with the moderate charge then in vogue. This construction led to the following general modifications besides those for strengthening the guns, viz, to the use of copper-banded projectiles, slow-burning powders, and the addition of higher calibers to those then in use; that is to say, up to a caliber of 12.61 inches (32^{cm}), weighing 77,160 pounds, and throwing a projectile of 770 pounds.

The French naval authorities were also influenced in the strengthening of the system of 1864 by the introduction of the model of 1870 by the recognition that heavier charges must attain to cope with the rapid strides being made in the application of heavier armor-plating to vessels, and the necessity of fully recognizing the principle that the transverse strength should afford as much surplus for meeting the longitudinal strains as was afforded in their construction for the provision for the tangential ones. A velocity of only 1,148 feet attained for the gun of 1864; and higher ones being a necessity, this also furnished an additional reason for seeking for a stronger system. The employment of short steel tubes was regarded as affording a full solution of this problem in 1870, and was accordingly introduced as above stated.

French authorities in 1873, alluding to the model of 1870, also claimed that—

> Experiments have shown that there is another advantage in tubing cast-iron guns with iron or steel, as important as that of increased resistance, and that is that the tube is the first to give way, preventing violent explosions.

Further—

> That later trials with our breech-loading guns showed that the steel tube, joined to its other general properties, had a special adaptation for breech-loading guns with a screw fermeture, the importance of which was very considerable. It increased up to almost a certainty, even against excessive efforts, the resistance to that which we call the "rupture of the breech," and which was the usual course of destruction of our guns of the model of 1864.

The general conclusion from the above is fully warranted, that pure cast iron, even fretted, after having been thoroughly tried for breech-loading guns in France, has proved for modern exigencies a failure, and affords additional evidence that, independent of its inherent weakness for even muzzle-loading guns as demonstrated by our own limited experience, it would prove decidedly unsuccessful for breech-loading guns if not at the very outset, yet in the early future; and that any attempt to solve the problem, especially regarding breech-loading gun construction, looking to its use, even fretted with steel bands (model 1864), would be disregarding the experiences of the past, both here and abroad, and that failure in all probability *would* be the result.

As indicated above, the model of 1870 is composed of a cast-iron body, fretted with puddled steel, and finished with a short steel tube introduced at the rear. These guns are manufactured at Ruelle, except the steel parts, which are fabricated at Le Creusot and St. Chaumans, and sent to the government works for completion and application to the cast-iron bodies founded at Ruelle. Some of the steel tubes and frettes, however, are the product of the works of Messrs. Thomas Firth & Sons at Sheffield.

The following general remarks regarding casting, frettage, and tubage, may be of interest in this connection.

At Ruelle, the furnaces are arranged in a circular manner and at the circumscribing walls of the foundry. They have in front of them the necessary permanent conduits, built in concrete, leading to the pits, which are also circularly arranged, occupying positions around the lifting cranes, which are placed near the center of the building.

The preparation of the molds and flasks, and the mode of assembling the sections, and other details for casting have nothing peculiar in their construction, and it only remains to notice here the general mode of casting. The most peculiar and striking feature in their mode of casting is that the cannon are cast breech up, and that the shape of the casting is nearly in conformity with the finished models of the bodies of the guns. Some are cast hollow, and some are cast solid, depending upon the size and kind of ordnance these masses are to be used in constructing. The heavier natures are cast hollow upon *solid* cores, which are withdrawn in as short a time as practicable after the metal has taken a sufficiency of set.

The process of hollow casting and internal cooling formerly employed has been abandoned; also no attempt to prevent the escape of heat by an outer covering such as a thick layer of sand, or its retardation by fires in the pits external to the flasks. It is claimed that the solidity of the piece is fully secured, and the metal as good as by the employment of hollow cooling, and that it is superior to the solid casting, and occasions a considerable saving in time in the boring and finishing of the guns.

In regulating the flow of metal in casting at Ruelle, two siphons or conduits are used in connection with the flasks; the first one introducing the metal into the mold at the bottom, and the second one continuing the casting as it rises, commencing to give its flow at about the middle of the flask. The flow from the lower siphon is, of course, discontinued when the molten metal has risen up to the débouché of the second one, which then comes into play in completing the casting. (See plate XVI.)

This mode of casting is objected to by some authorities on the ground that the floating and rising slag might become incorporated in the body of the casting when the upper conduit is first opened, and thus result in a porous casting; also that the slag tends to obstruct the flow of metal from the second siphon.

FRETTAGE.

It may be of some interest to note, shortly, the introduction and development of hooping cast iron with steel bands in strengthening the former material in gun constructions. It appears that the first attempt was made in 1836, at the founderies of Liege, in Belgium, where the minor powers of Europe, and even Russia, procured their cannon at that time; resort being had, however, also to the well-known Swedish founderies of Fingspong and Aker.

The method was first brought into notice at Ruelle, in 1843. It was introduced a few years later by Blakely, in England; and in 1859 it was tested again in France, at Vincennes, by the navy department, and officially adopted for all its rifled guns. In 1864, in the model then adopted, the exact allowances for shrinkage were established, based upon both practical and theoretical observations.

The allowance for shrinkage, it is intended, shall be such as to secure a compression of the interior strata according to the theories of Gadolin and Lamés. The amount of diminution of diameter of tubes varies from 0.003 to 0.007 inch.

It is hardly necessary to allude to the fact that the large constructions for naval service have two series of puddled steel frettes, made at Le Creusot and Rive de Gier.

The banded portion of the cast-iron body is, according to general rules, about one caliber in thickness, and the bands 0.25 caliber for each row, giving a thickness at the seat of dangerous pressures of about one and one-half calibers.

The operation of shrinking on the hoops requires but simple and ordinary appliances. An oven, modeled after the ones employed in England for heating tires for wheels, supplies the means for heating up the frettes to the proper temperatures. They are transferred from thence by means of a small crane, and are placed in their proper positions on the exterior of the prepared cannon body by two or three workmen. A circular tube and collar containing water, which escapes in jets on to the superimposed frette, supplies the means for cooling. It is applied not directly after the placing of the frette in position, but in about ten minutes after the latter operation has been completed.

After preparing the body, and the assemblage of the first row of bands, the gun is transferred to the boring lathe, and the exterior of the frettes accurately turned, and the preparations for the application of the second row of bands completed. After this row has been superimposed the gun is sent to the machine-shop for the final process of fitting the fermeture, rifling, and other necessary work to complete the manufacture.

Proof-frettes are tested for elasticity, and proof of endurance by a shrinkage test. A cast-iron cylinder is used over which the experimental hoops are placed under a definite tension by heat, and when the parts are cut the cylinders are broken up and the frettes under proof measured and otherwise examined. A shrinkage determined upon, say, nearly up to .002 of the diameter, and a slightly less one for trunnion bands, should attain without any permanent set resulting in enlargement. They should withstand an enlargement not exceeding .004 without rupture, or development of serious superficial defects sufficient to warrant rejection. Based upon these trials, the frettes are prepared which are to be used in construction.

In the application of frettes or trunnion bands to the bodies of guns the establishment of the limits of shrinkage must largely depend upon the results of the testing machine for physical properties, and limits which may be determined by one set of experiments may be non-concurred in by another, operating on different metals used in different countries. The data resulting from French experiments are, therefore, matters of interest, but furnish no definite standard for following absolutely when other steels are used.

TUBAGE.*

The object of the introduction of steel tubes in the French naval cast-iron guns was, primarily, to give increased strength—especially, as above stated, longitudinally—and incidentally to give a surface of bore more perfect in its capacity for resisting erosion and gutterings from the deteriorations arising from the contact of powder gases.

The increase in longitudinal strength was a *sine qua non* as exhibited by the failures of the fretted model of 1864, and this point alone demanded the introduction of tubes.

The introduction of thin tubes merely to protect the bores had been repeatedly tried, but they added but little strength, although the wear of the bore appears to have been retarded. The present short steel tube has been the result of the essays in the tubage of guns; and the general dimensions of this part of the system of the model of 1870, with reference to the body and other parts, are shown in Plate XVII.

Colonel Sebert, in 1873, referring, in connection with the model of 1870, to the subject of tubage, states as follows:

> The most difficult part of the operation was the manner of securing in the casing the tube which receives the movable breech screw.; it is this mode of attachment, and the use of a short tube not extending further than the chase of the gun, which distinguishes the method adopted by the navy. A short tube was adopted because, as regards strength, it is only the rear part of the gun which needs reinforcing, and because a tube the length of the gun, in the *present state* of the steel industry, would increase the difficulties of fabrication.
>
> The first experiments with tubes made by the navy department related to muzzle-loading guns.
>
> I will not take up in detail the different systems successively examined, tests of which have been continued without interruption since 1864. I will limit myself to a description of what was absolutely adopted.
>
> The soft steel tube, tempered in oil, is prolonged to a little in rear of the trunnions, where the gas exerts but feeble pressure. It is reinforced in rear, and this reinforced part, designed to receive the breech plug, is itself screwed into the casing.
>
> The thread of the screw designed to secure the tube was one of the points which demanded most study and gave the greatest difficulty; a form was finally determined, so arranged as to secure solidity to the system.
>
> The tube, with its diameter larger than that of its casing by a slight amount, determined by calculation, was inserted into the gun, which was in a vertical position, and heated to a low temperature in order to give it just sufficient expansion. * * * The tube having been inserted until the shoulder of its reinforced part rests against the plane of the breech, is given a rapid motion of rotation, which screws it in, and forces the front of it firmly against the bevel connecting the bore of the casing with the counter-bore.
>
> By this process, the tube is compressed in the part comprised between the front bevel and its shoulder held by the screw-thread. This compression arises from the cooling and shrinking of the gun, and, inversely, the gun is subjected over the same length to a longitudinal extension.
>
> This double condition appears to be essential to the success of tubage. I will not stop to explain the considerations which enabled them to ascertain this fact; it suffices to say that the amount of longitudinal shrinkage, for each caliber, is exactly determined by calculation, the same as the diametrical shrinkage of the tube. The gun, once it has been tubed, ordinarily receives an exterior frettage.

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* By tubage the cast-iron screw seat is replaced by a strong and hard screw-thread in steel, and by theory the strain on the cast iron, on a somewhat greater diameter of the weaker metal, increases its resistance to rupture by the *breech strain* at the initial point of the screw in the cast iron, where rupture is liable to occur and "déculassement" ensue. By not confining the length of the tubage to a mere fillet of steel, but by extending it along the bore some distance, we undoubtedly further relieve the strain on the cast iron at the screw seat by the hold the tube takes on the cast-iron body in front of the breech, resulting from the friction arising from the transmitted tangential strain in firing. This friction evidently tends to prevent a rearward action of the tube, and acts counter to the strain on the breech, and hence considerably believes the cast iron at that point.

Numerous experiments have shown the success of this system. By experiments with various calibers, and by the final employment of excessive charges and violent powders, the manner of the destruction of these guns has been examined. It has been thus shown that the object desired has been fully attained, that is to say, that the resistance to the blowing out of the breech now predominates over the resistance of guns to transverse rupture, and that consequently at the limit of the life of the gun, and supposing the use of ordinary service charges, rupture announces itself by cracks of the inner tube, which thus prevents all danger of premature explosion.

It may be interesting to know the increase of resistance which frettes and tubes together give to the naval guns. The following are the results on the subject, determined by calculation. These data are taken from the memoir of Colonel Virgile; they apply equally to all our guns, which have the same thickness, one and a half calibers:

1st. Guns of Ruelle, cast iron, without either frettes or tubes, the cast iron standing 11,257 pounds per square inch, offer a resistance of 10,000 pounds per square inch.

2d. Similar guns with a single row of frettes, the cast iron standing 11,257 pounds per square inch, and the puddled steel, 35,600 pounds, have a resistance of 20,000 pounds.

3d. Guns with two layers of frettes, for a mean tenacity of the casing and frettes, reach 24,700 pounds.

4th. The same guns with tubes reach 45,900 pounds. The addition of frettes and tubes more than quadruplicates the original strength of the cast-iron guns.

The appliances for the heating of the cast-iron bodies for the reception of the steel tubes are marked by great simplicity. A cylindrical furnace, sufficiently large in its interior diameter for the gun or guns to be heated, is extemporized on the foundry floor, and of a sufficient height to receive fully that portion of the gun necessary to be heated up sufficiently to give the necessary expansion to the cast iron for the easy and free insertion of the tube. It is placed over a pit, and the projecting portion of the chase is thus provided for when the gun is lowered into the furnace.

The general features of the furnace are a brick exterior wall, dry built, and provided with proper interstices as successive layers are added in the course of its erection. A thin iron cylinder constitutes the interior walls, and the intermediate space is filled with wood fuel to furnish the necessary heat. Tie-bolts, radial and lengthways of the extemporized furnace, are supplied to give the necessary strength and solidity to the system. (See Plate XVIII.)

The gun, of course breech up, is inserted into the furnace by the crane or cranes of the foundry, and after the insertion of the tube is sent to be finished by the subsequent operations of frettage, provision of breech-block seat, truing up of bore, rifling, &c., and its final completion for service.

The naval calibers are 14^{cm}, 16^{cm}, 19^{cm}, 24^{cm}, 27^{cm}, 32^{cm}, 34^{cm}, 37^{cm}, and 42^{cm}. The three last have only recently been added; and the four 42^{cm} guns, now in process of construction at Ruelle, are the first of this model. These guns, with one exception, are all steel, and are built up of thick steel tubes, tempered in oil, and with two tiers of frettes of puddled steel shrunk on. The tubes are the product of Le Creusot, and are cast from Siemens furnaces, and forged under the large hammers of those works. Only three of these, however, have a full steel construction; the fourth differing from the others in having a cast-iron body instead of a steel one.

This latter is intended purely for ballistic purposes, and to be used as soon as completed at the polygon of Gavre. The weight of the steel gun is 75 tons; the weight of the experimental gun, however, is 100 tons; the French engineers giving 25 *additional* tons weight for the *same caliber and power* when cast iron enters as a component in the system as a substitute for the steel bodies.

The details of these guns (42^{cm}) are as follows:

Length of the bore in calibers	22
Weight in tons	75.4
Weight of bursting shell ....pounds	1,736
Weight of the charge ....do	617.3
Initial velocity ....feet	1,738
Living force in foot-tons	36,628
Living force per ton of metal	485.8
Living force per pound of powder	59.3
Living force per inch of circumference	70.8

The 34^{cm} guns of the model of 1875, now being built, may be next mentioned.

The following are some of the dimensions and other particulars regarding them:

Length ....meters	10.265
Length of bore ....do	9.69
Length in calibers	28.5
Weight ....tons	51.6
Charge ....kilograms	210
Shot ....do	420
Muzzle velocity ....meters	596
Mean pressure in chamber per centimeter ....kilograms	2,800
Estimated penetration ....centimeters, iron	74

This model has, however, several varieties, differing in weights and dimensions, save, of course, in caliber, as follows:

	1.	2.	3.	4.
Total weight ....tons	43.3	47.2	48.2	51.6
Bore:				
Diameter ....inches	13.38	13.38	13.38	13.38
Length ....do	241.4	281.4	334.9	381.3
Length ....calibers	18.0	21.0	25.0	28.5
Chamber, diameter ....inches	13.82	13.82	13.82	13.82
Velocity at muzzle ....f. s	1,722	1,788	1,886	1,962
Pressure in powder-chamber ....tons per square inch	17.8	17.8	17.8	17.8
Perforation of back-plate:				
At muzzle ....inches	24.4	25.6	27.6	29.1
At angle 20° ....do	22.4	23.2	25.2	26.8
At 1,000 meters At 1,094 yards	21.3	22.4	24.2	25.6
At an angle of 20° ....inches	19.7	20.5	22.0	23.2
Tube ....tons	19.0	21.5	23.0	24.5
Hoops ....do	23.2	24.5	24.5	26.3
Breech apparatus ....do	.97	.97	.97	.97

NOTE.—The above record dates in October, 1881.

These guns are built up, having a thin steel-tempered tube encased under shrinkage, in forged steel bodies, made in two sections, and are completed by the superposition of puddled-steel hoops. (See Plates XIX and XX.)

The more marked features of this system are the amplitude of power contemplated, rivaling, as it does, the best efforts of the Armstrong steel construction; a weight of charge one-half the weight of projectile being designed, and a calculated muzzle velocity of 1,962 feet being expected to be attained. The weights of the different lengths for the same caliber varying from 43.3 tons to 51.6; and the muzzle energy secured is, say, about 20,000 foot-tons, or about 400 foot-tons, roughly, per ton of metal.

The shortening of some of the guns is found necessary to adapt them for vessels not admitting of the 28½ calibers standard for length.

It will be observed that the chambering has only an increase of about

0.44 inch above the bore, a marked difference between it and the English chamber and those proposed in the United States. It is, however, to be noted that the importance of using chambers has not escaped the attention of the French naval authorities, as the introduction of larger chambers in guns of the model of 1870 is one of the features of the work now being executed at Ruelle; recent experiments at Gavre having shown the feasibility of their application to the model in question.*

About 10 per centum in capacity of chamber is added to the original 12.59-inch model of 1870 gun; and the resulting muzzle velocity, using the normal shot with an increase in the weight of powder by 62 pounds, has been increased 40 feet.

It is understood that besides the 32^{cm} guns being altered, that the lower natures of model 1870 down to 14^{cm} will be chambered to further increase their power. The power, however, attained by these guns is far inferior, caliber for caliber, to that attained by their more formidable rivals built up of steel, now being prepared for introduction into the French marine.

The following references regarding the power of these guns may be of some interest. From tables believed to be as complete, generally, as can be obtained, it will be seen that, including the Dard model and the latest 34^{cm} guns now in process of construction, the ratio of weights of powder to projectiles is one to two, and one to three where steel alone is used; one to five in the model of 1870, steel tubed and fretted; and one to six for the model of 1864, which latter are no longer standard.

In our service, unchambered 8-inch have a ratio of one to five, as in the French model of 1870. Our experiments leave as yet in dispute the propriety of using a ratio of 1 to 3¼, as contemplated in the chambered breech-loading 8-inch recently tested at Sandy Hook.

The maximum velocity contemplated for constructions, all steel model of 1876, is 1,625 feet; with model of 1870, 1,404 feet, and with model of 1864, say 1,100 feet. These velocities are those appertaining to the caliber of 27^{cm}. As above stated, however, 1,962 feet is calculated for the more recent construction of (1880 and 1881) caliber 34^{cm} gun.

Referring to the 27^{cm} gun, it may be stated that the weight of the projectile is the same for all models cited (1864 to 1881); the charges, however, differing from ½ up to ⅙ of the weight of the projectile.

The resulting foot-tons of energies at the muzzle for the different systems of construction, taking as a caliber for comparison the 27^{cm}, are as follows:

	Foot-tons.
Model of 1879 (steel)	12,677
Model of 1875 (steel)	8,695
Model of 1870 (cast iron, tubed and fretted)	6,491
Model of 1864 (cast iron, fretted)	3,983

The energies per ton of metal in the different systems are approximatively as follows:

	Foot-tons.
Model of 1879	410
Model of 1876	322
Model of 1870	288
Model of 1864	200

The calculated pressures for the models of 1870 and 1876, are, respectively, per square inch, about 35,500 pounds for the former, and 41,000 pounds for the latter. The difference in these pressures, which it is believed occur in service, although sensibly different, show that the cast-iron fretted constructions of 1864 were—by the powders adopted for their service—less severely strained than the constructions of 1870 and 1876.

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* It is stated that the largest French iron-clads now in progress of construction are to be armed with 100-ton guns.

No more glaring evidence of the inadequacy of cast iron when compared with the combination of this metal with steel tubes and frettes, or with steel constructions simple and pure, can be exhibited than shown by the above figures.

That modern constructions within the present resources of metallurgy can attain at least double the energy per ton of metal (leaving out the question of endurance), when compared with the cast-iron constructions of the past (although fretted with steel), leaves no reasonable room for argument on the advisability of the further use of cast iron alone and simple, and shows that its employment at all in gun constructions is only warranted by the fact that a safe construction, but of comparatively low power, will probably be the result of its combination with tubes and frettes of steel, and that hence merely an economical construction as compared with the use of steel will be secured.

It must not be forgotten, however, that not only lower power is a drawback, but that although the steel constructions cost per pound about 2.9 times that of the cast-iron tubed and hooped gun, yet the endurance of the former is estimated at about three times that of the latter. The latter fact amply compensates for the excess of prices, especially in those guns which may be called upon for continuous long-continued firings, as in the cases of the defense of seaports—particularly large harbors exposed to continued and renewed attacks—and ship armaments, where the great lightness, power, and strength of steel ordnance become matters of vital importance.

In cases, however, of secondary lines of defense, such as those positions where inferior power will suffice, and where less continuous demands upon the resources of the protecting batteries will be made, and where the guns will not be called upon to cope at short ranges with blockading squadrons, the inferior and cheaper constructions can be utilized; and for such should, in consequence, have preference. In many of these cases the guns will never be used, and will have probably become obsolete before any demands upon them, beyond practice, will be made.

The original model of 1875 (see Plate XIX), a construction in steel, is designed, generally, after its prototype of 1870, to which it is a natural sequence growing out of the experiences of ten years of test and manufacture of the latter, aided by the developments and advancements resulting from the rapid strides in France and England in the production of steel.

Its salient features, as above stated, are a steel, oil-tempered tube (*held simply by shrinkage*), placed in a steel body consisting of two parts of about equal weight, united by locking together, the whole strengthened by two rows of shrunk-on frettes, superimposed over the body. The fermeture placed in the rear section of the body has no connection with the interior tube. This construction generally gives all the advantages to be derived from the use of the strongest and most suitable metal for ordnance; is built up in accordance with the theories of construction for tangential strength, as far as they can practically, and with due regard to economy be applied; and by the separation of the inner tube from the body, disconnecting the end strain from the tangential at this point, introduces a feature constituting a true and important departure from the ordinary mode of construction now in vogue. The *failure*, however, *to lock* the tube to the body—to prevent the forward thrust of the former, arising from the friction of the moving projectile, and the gases operating on the shoulder of the chamber—save by the friction between the tube and body, is a *radical* defect, and *experience* has developed it and led to a modified form of construction. This modification is shown in Plate XX.

It consists of a hollow cylinder screwed into the casing, and with sufficient length to afford a rest for the fermeture, and to afford a means of being locked to the interior tube. This, of course, will prevent the tendency of the tube to move to the front; and it was this cause, it appears from recent French authorities, that led to the modifications just noted. They say, alluding to the original model of 1875:

> Ce mode de tubage n'a pas donné de bons résultats, ainsi que la remarque en a été déjà faite dans le 1er chapitre à propos des canons modèle 1875; la fixité du tube *n'est pas* suffisamment assurée.

In this modification, the junction of the inner tube and body takes place practically at a point equivalent to the bottom of bore in muzzle-loading guns; and as the phenomena in the act of firing in a breech-loading or muzzle-loading gun—the breech-loading gun using a French fermeture—are essentially the same, it is believed that all the disadvantages arising from having to contend with the union of the *two* strains at the bottom of the bore still attain in this construction. Therefore the union as proposed in this report (see Plate VII) seems to me to be preferable.*

The absolute separation, however, of the longitudinal and tangential strains by designs in construction which shall contemplate entirely different parts of the system to separately withstand these stresses, is now one of the most prominent ideas which is engaging the attention of the ordnance constructors of the day.

The first inventor to believe that an advantage might be gained by the complete separation in a gun construction, *united in all its parts*, of the tangential and longitudinal strains at the breech was, as far as I can judge, Captain Emile Schultz, of the French artillery, who, as far back as 1875, shows, in one of his illustrations of a wire gun, a design giving a practical application of this idea. The plan is shown in the plates XXVI and XXVII (attached to patent specifications, 1875) in this report.†

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*In this connection, attention again may be invited to the practical experience had both here and in England of the power of the drawing forces exercised on the *surface of the bore* by the friction arising from the passing projectile and the powder gases. The gases operating on the bottom of a closed tube, as a point d'appui, hold it from any forward movement, and the grip of the projectile from friction tends forcibly to drag the *metal immediately around the surface of the bore* to the front, elongating it, and leads to a longitudinal rupture commencing at the surface, and finally extending through the thick tube, as in the case of the Duilio gun, or in the case of a lining-tube with a bottom, of forcibly rupturing it, and dragging it out of the body of the gun, and projecting it to the front, as in the case of the English and American guns which have been so disabled. No such phenomena can occur if the inner tube is bottomless and firmly secured to the superimposed body as described in text and by Plate VII.

Further, a comparison of muzzle-loading wrought-iron lined guns with the 8-inch breech-loading lined gun tested at Sandy Hook—the latter having a bottomless tube—tends to confirm the advantages of this construction. In the former, long and deep coil-weld marks attained in proof, whereas their absence in the latter was particularly marked.

†Prior to 1875, various plans for loading heavy ordnance at the breech (for instance, see appendix of Report of Board on Heavy Ordnance 1872) were in existence, in which the feature of the division of the tangential and longitudinal (breech)

It will be seen that the jacket, superimposed over a steel tube wrapped with wire, is secured to a breech-block receptacle, the fermeture when in position for firing simply abutting against the rear face of the tube in which the charge is wholly contained.

Referring to the experiences in the French service, which showed the absolute necessity of the introduction of some means for the prevention of *déculassement* in the fretted cast-iron guns of model of 1864, we see that reinforcement with interior steel tubes was the remedy resorted to to remove the evil. A separation of the two strains appears to be a more radical treatment, and it is even probable that a cast-iron fretted or wired gun, *without an interior tube*—the longitudinal stress being borne *outside* of the body of the gun—might be tried as promising a fair solution of the problem for guns of a secondary order of power, if not too cumbersome and heavy in construction. A general plan is herewith presented combining these features with a *steel body* with an interior bottomless tube, wrapped with wire, and protected by a steel, or soft metal, jacket. (See Plates XXI and XXII.)

It is thought that experiments can safely be commenced with a 9-inch caliber, and the plans are so presented.

A successful construction of a 6-inch or 8-inch caliber, using even the materials and appliances at present at our command, or shortly to be so, is reasonably assured by our experiments here, and if any guns of these calibers are required, we can readily produce them, making judicious modifications, the means for which are, it is believed, within our control. Motives of economy, amongst others, dictate this view, and from these considerations and others above stated, I believe that the *French model* of 1870, for calibers at least up to 8 inches, could be safely introduced. For higher natures, where *weight* becomes, amongst other considerations, a matter of grave import, I think, as above set forth, that we must resort to pure steel constructions, using either wire-wound or steel-jacketed *steel* tubes.

A cast-iron gun lined and fretted with suitable steel, and judiciously proportioned or modeled after the latest constructions of 1870, will give a powerful and in all probability a safe gun; and, from these considerations, and considerations of economy, and the *present developed resources of our country*, and those reasonably to be expected in the near future, is a system worthy of consideration for immediate test in the *heaviest* ordnance.

Although reliable guns of high power will probably result from this construction, yet it would seem that a compact and strong provision for the longitudinal stress outside of the body of the gun will be an improvement even in this type of ordnance.

This system has been so thoroughly developed that it seems to me that it should be taken for granted that its principles are well established, and that hence experiments should only be made with the higher calibers decided upon as required.

Halting here, however, would be doing injustice to the subject of the provision of an adequate and powerful sea-coast armament, and hence every effort should be made to develop our resources in the production

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strains appear; but these features were accidental and entirely subordinate to, and the outgrowth of, the peculiar modes for opening and closing the breech.

Schultz's model of 1875, it may be further stated, is a built-up gun, its parts *not* to be separated in loading, and one in which the different strains are supported by parts independent of each other. The fact that he used a then old device for closing the breech, confirms the view that his separation of strains was fully contemplated, and was not a simple sequitur in his wire-gun plans of 1875.

of the superior metals, and gun construction should, by experiments, keep pace with the advancements made, as time passes, in the production of steel for ordnance, and that problem should not be permitted to rest a moment, until we have at our command resources which will enable us to promptly and successfully produce guns of the highest power, combined with light weight and strength.

SCHULTZ WIRE GUN.

The successful test in France of a 6-inch wire gun on the Schultz plan has given such an impetus to the development of this mode of construction, that not only the French naval authorities have decided to push experiments in this direction on a large scale, but also, as set forth in this report, English manufacturers have made, and are making, rapid strides in the development of systems involving the use of steel in this form.

No fewer than six experimental wire guns are now in process of manufacture, varying in caliber from 34 centimeters to 10 centimeters.

The steel (*oil tempered*) is made at Saint Chaumond; the wire used is known as piano-wire. The guns being wound, or to be wound, are to be finished at Lille; and where cast-iron bodies are used, they are the product of the foundry at Ruelle.

In October, 1881, the 34-centimeter gun was in such an advanced stage of progress that its completion was expected in three months, and the experiments with it are contemplated to be made this ensuing summer at Gavre.

The 34-centimeter gun has a steel body, as before stated; but the four 24-centimeter guns—indicated on the list as experimental guns—are to have cast-iron bodies; and one or two of the latter had been cast in September last, and were in process of boring and finishing at my visit to Ruelle last autumn.

A 10-centimeter gun completes the number of experimental wire guns at present contemplated, and is now ready for trial.

Referring to the 34-centimeter gun, it may be here stated that wire 0.118 inch in diameter, to the extent of 43 layers, is wound round the body, giving a wire thickness of about 4.42 inches, the exterior to be covered by a cast-iron jacket to protect the wire. The breaking strain of the wire is reported at 200 kilometers per millimeter, and it is put on under a tension of about one-third its ultimate strength. Longitudinal strength is given by 12 steel rods of about 7½ inches in diameter, passing from the trunnion-ring to the breech-block receptacle, and secured at each end by suitable nuts. One statement gives the charge at 440 pounds, with a 900-pound projectile; another as 330 pounds powder and a 990-pound projectile.

The 24-centimeter guns—cast-iron bodies—are all to be unlined except one, which is to have a short steel tube. Thirty-five layers of wire about 0.″8 thick from breech to center of trunnion-ring, and 16 layers from thence to about half the length of the chase, complete the wire wrapping. A jacket of copper over all, of 8 millimeters thickness, is to be superimposed over the wire. The breech-blocks will be steel, and will be secured as in the case of the 34-centimeter gun. These guns are expected to be finished in two years.

The following table gives some of the principal dimensions of these guns, and other data:

Kind.	Weight.	Caliber.	Chamber.		Length of bore.	Breech-piece.		Charge.	Projectile.	Velocity (estimated.)
			Length.	Diameter.		Length.	Diameter.			
	Tons.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Pounds.*	*Pounds.*	*Feet.*
34.........c. m..	50	13.4	60.23	14.56	354	189	59	440	935	....
24.........c. m..	18	9.44	56.3	11.4	269.25	....	....	176	352	2,362
10.........c. m..	1.3	3.93	19.15	4.9	81.4	....	....	16.72	33	....

It will be seen by computation that Captain Schultz has an extraordinary excess of longitudinal strength, amounting—taking steel rods at 100,000 pounds per square inch—in tensile strength to over 50,000,000 pounds. The pressures on the bottom of the chamber or face of the fermeture would only be about 6,000,000 pounds, taking the gas pressures at 40,000 pounds per square inch. This ratio of resistance to pressures to be withstood, even if somewhat abnormal, seems excessive, and although it is necessary to keep, in providing for the strains, within the elastic limits of the metal used, yet even then we have a larger reserve than seems at all necessary. It results, it seems to me, in an unnecessarily cumbersome and also weighty structure. The diameter of the breech-block is stated to be 59 inches; and it is estimated approximatively (no complete drawing is available) that the walls do not exceed nine-tenths of a caliber in thickness, if they attain that limit.

With the data given, a tolerably accurate drawing of the system in its general features can undoubtedly be produced. Heretofore, attention has only been had to the disposition made, looking to the securing of strength by the introduction of the feature of division of strains at the bottom of the bore.

The mode of securing the ends of the wires is one of the greatest importance, as the initial tension of the applied wire in gun construction is, as a rule, about one-third of the breaking weight. Armstrong, it is believed, uses at least two plans, one set forth in his patent specifications, and the other illustrated by the accompanying plates, Nos. XXIII, XXIV, XXV, showing his mode of wiring cylinders for comparative tests (for tangential strength) with all steel cylinders, using gunpowder to rupture them, which are both free from longitudinal stress.

The plates briefly show:

Fig. I, a cylinder as prepared with recesses to secure the ends of the wire with a plug, as shown in Fig. 5.

Fig. II, a section of Fig. 1.

Fig. III shows, in part elevation and part section, the wire as wound round R. G. F. steel cylinder. It is fitted with steel end-pieces. They contain the crusher-gauges, and one of them is also drilled for a vent; both ends are then fitted in, and wrought-iron supporting hoops are fitted over them. Each layer of wire is fastened at both ends separately, with ⅜-inch screws, as also shown in Fig. 6, and at section A B.

Fig. IV, same as Fig. 3, with the difference of a steel hoop instead of wire.

Fig. V shows ends of wire secured by plug.

Fig. VI, ends of wires secured by screws, as shown in elevation and section through A B.

Capt. Schultz, from the imperfect data before us, appears also to have contemplated two plans; one to be hereafter alluded to in presenting his plans of 1875, and the other regarding which my information, as obtained at Paris last fall, is vague and incomplete. "Barots"—small hardened steel pieces—placed at the termini of the wire layers, in recesses in the flanges of the steel core or body (between which the layers are placed), are the recipients of the wire in the second plan. These "barots" are slotted across, the slot being of a less width (at the middle) than the diameter of the wire (which is driven into it with a hammer), so as to leave about two-thirds of the strength of the wire as a bind. As the tension is about one-third of the ultimate strength, sufficient tensile strength is left to securely withstand the pull of the tensed wire. The shape of the "barot" is shown on Plate XXVII, Fig. 5.

Captain Schultz presented his plans, as then matured, to the public in the United States, under a patent secured by him in 1875. The essence of the description of his plan and the illustrative plates are given as of interest, and as throwing some light upon his invention. Since then, it may be remarked, he has resorted to steel rods to secure his breech-block, as shown in Plate XXI.

His patent specifications are as follows.

His mode of fixing the piece upon the carriage is, of course, only incidental, but it is quoted as a matter of some interest:

> The first part of my invention relates to that class of cannon in which the tube or barrel is enveloped in a coil of wire under constant tension, and it consists in a method of fastening the end of the wire, while under tension, by driving it into a slot smaller than the diameter of the said wire. The second part of my invention relates to a method of fixing a piece of ordnance upon its carriage, by the combination of a trunnion case or cylinder with bearing ring formed on the cannon, and elastic bodies, whereby the shock of the piece against its carriage will be transformed into a continuous pressure, also to a method of lodging the cannon in the rear end of the trunnion case or cylinder, so that it may pivot round the axes of the bearing-ring to permit the lateral pointing of the cannon without displacing the trail.
>
> On the accompanying sheet of drawing (Plates XXVI and XXVII) Fig. 1 is a longitudinal section of a piece embodying my invention, Fig. 1*, a lateral section of same by XY; Fig. 2, end view of the breech, Fig. 3, lateral section of a piece following the lines A, B, C, D, E, of Fig. 4. Figs. 4, 5, 6, 7, and 8 illustrate the fastening of the wires on the piece. Fig. 9 shows breech-screw with threads cut following helicoidal lines. Figs. 10 and 11 are longitudinal sections of two pieces with variable strength or resistance from the breech to the mouth.
>
> A indicates the central tube of the cannon, around which the wire coils at B; C, faces which limit the space reserved for the wires; D, channel in which meet the ends of all the rows of wire; H, ring carrying wire fastenigs; M, casing or jacket enveloping the tube, and carrying the breech and the fastenings for securing the piece upon its carriage; N, screw fixing jacket at the back; O, cylinder with trunnion P; P′, rear end of cylinder; Q, ring or cannon bearing against india-rubber washer R; S S, flattened parts of cannon; *a*, a slit of rectangular section, in tempered steel piece *b*; *l*, projection on jacket abutting against *m*; *pp*, springs or washers of india rubber; *rr*, sheet-iron washers.
>
> *Method of fastening the wires.*
>
> The method of fastening must meet several requirements; it should be sufficiently simple to occupy but little space; it must be absolutely secure; finally, the fastening must take place while the wire is supporting the coiling weight, and without any variation of its tension. A means of attaining this object consists in squeezing several wires between two pieces with corrugated surfaces, intended to produce gentle curves in the wires. The squeezing of these pieces is obtained by screws or by wedges; but the means to which I give preference, and which I claim as my invention, consists in inserting the wire into a slit, *a*, of rectangular section, made in a piece of tempered steel, *b*. The width of this slit is slightly less than the diameter of the wire. The result is that the wire, being sunk into this slot, is cut against the sharp edges of the steel, two small segments are removed, and the wire forms a real riveting, *a*, Fig. 8. The pieces of steel forming fastenings are set transversely to a channel, D, where meet the ends of the wires of all the rows. The wire which it is desired to fix comes

on to the edges of the slit, and while still remaining under the tension of the weight which it supports, a blow from a hammer is sufficient to drive it into the slit, and the fastening is thus completed without any variation of the tension.

The mode of fixing the piece upon its carriage.

The preservation of the carriages is very difficult in the case of light pieces firing with heavy charges, and to obviate this defect it has been proposed to interpose steel springs between the piece and the carriage. To attain the same end I use the following method of mounting the piece: For this purpose a cylinder, O, Figs. 1 and 1*, having trunnions, P, is set in the ordinary manner on a carriage. The piece may slide freely in this cylinder like a piston. In the space left between the cylinder and the piece are placed springs or washers of india rubber, *p p*, analogous to those used for the buffers of railway-wagons, and separated by sheet-iron washers, *r r*, intended to isolate and center them. These washers bear against the rear end, P′, of the cylinder. The cannon has a projecting ring, Q, which bears against the india-rubber washers, or the steel springs, and compresses them under the effect of the recoil. An india-rubber washer, R, is interposed between the ring and the front end of the cylinder to deaden the return shock of the piece when it is brought back to its primitive position by the distension of the compressed washers.

The object of this arrangement is not to lessen the recoil, but to deaden the shock of the piece against its carriage, by transforming it into a continuous pressure.

This arrangement presents another advantage, namely, that of permitting the pointing to be completed without displacing the trail. For this purpose it is only necessary to leave a slight play at *s* for the lodgment of the piece in the rear end of the cylinder, so that it may be moved latterly to a slight extent by pivoting round the axis of the bearing-ring, Q, against the washers.

The opening left for the passage of the piece into the bottom of the cylinder is made following a straight line horizontally. The piece carrying flattened parts, S S, rests upon the lower horizontal surface of the opening, and the play only exists laterally. Fig. 1* shows this arrangement.

Two screws or an eccentric permit moving the piece in this opening, and giving it a certain inclination on the axis of the cylinder.

Referring back to the notice of a 9 inch construction on the Schultz plan (see Plates XXI and XXII), the following brief remarks may be made regarding its general features.

Assuming 40,000 pounds pressure as a normal strain, and placing the tensile strength—attainable in good quality steel rods—at 100,000 pounds per square inch, it results, approximatively, that we have a ratio of strength to resist the stress on the face of the fermeture as at least six to one. The strains would have to be largely abnormal to reach the elastic limit of the rods, or, say, 80,000 pounds gas pressure per square inch, allowing 40,000 pounds per square inch as the statical pressure at which permanent set will take place. That solidity which insures the maximum of rigidity appertaining to undivided constructions is, however, wanting in this construction, and hence we have to contend with a tendency to a spring in the bolts, which is aggravated by repeated straining, and a vibrating action which will possibly sooner or later result in a tendency at each discharge to cause a transient play between the divisions of the gun, causing a slight momentary separation between the fermeture and the gas check.

The advantage of separation of strains would be almost altogether lost if we attempted to screw the fermeture partly in the breech-block and partly into the body of the gun. This presumed possible disadvantage, however, can be fully met, it is believed, by the introduction of the de Bange gas check—a check now adopted in the French land service, even up to the highest calibers (24 centimeters), both for pure steel and cast iron and steel constructions. It will be described under the head of French Heavy Ordnance for land service. It is only necessary to state here that it is a check of extreme simplicity, cheap, light, readily applied, sufficiently durable, is replacable; is standard in the French army; is being developed at Woolwich, starting from 28-pounder guns, in which it has proved a success; and that it requires no gas seat or enlargement of the chamber or bore to receive it. Its advantages in the construction under consideration are, that it *finds its seat* in firing not necessarily at one point, but that it has a tolerance in this regard, and hence can perform its functions under a play which cannot be successfully allowed for in the seating of the Broadwell ring, now universally used in obturation. This latter, however, can undoubtedly be used, but it is apparent that if desirable to experiment with the de Bange plan it can be readily and inexpensively tested in any construction, which is evidently designed for the Broadwell ring and the French fermeture, advantage being taken to test the former system prior to the application of the metallic gas-check obturation.

It is proper, however, to state here that some objections have been raised regarding the de Bange check by the French naval authorities; the principal imperfections alleged being deterioration of the checks by repeated firings, and by time and climatic influences; and also a liability of the stem of the "mushroom head," between which latter and the face of the screw fermeture the check works. The difficulties of securing a central fire may be increased, but it is not seen but that by increasing the diameter of the *queue* of the roudellen, or "mushroom head," that objection and also that of liability to breaking of the *queue* can be satisfactorily met.

The general principle that a great advantage cannot long remain subordinate to increased difficulties in securing other desideratums will soon vindicate itself by inventions affording a solution of the difficulties surrounding the problem. These imperfections, it seems to me, if they prominently exist, are of such a nature as to be easily overcome; and I am sustained in this belief by the fact of the universal application of this mode of obturation in the French land service, and the successful experiments with it in Great Britain.

The model presented has thirty calibers of length; eight steel rods 5 inches in diameter, to support the breech-block; the steel tube—fluid compressed—and the wire to be wound and fastened after any well-known good plan for securing the ends; and the gun finished after any of the common modes of jacketing or hooping. Its weight should not exceed 18 tons.

One of the advantages of this rod system, it will be seen, is that the rods can be replaced when their elasticity is gone, *and as long as the body of the gun is intact, the gun is repairable.* The number of rods in this mode of construction should not, it would seem, be less than four; but the minimum number which can be used to the best advantage will give us greater stiffness in the system, and the number for this reason should be made but few, due regard being had to the demands in dimensioning and fastening the other parts of the construction. In the Schultz system it will be seen that cast iron, as well as steel bodies, are contemplated; and in such a system only can cast iron without tubing be tolerated even for secondary purposes.

If the division of strains with wiring or fretting can make it available, yet inferiority in strength and reliability, besides other objections, *must result*, and we have but at best a make-shift construction. The cast iron, besides, is more subject to deterioration by the action of the powder, and such guns present less endurance (about, say, one to three) than the others of the *same system* having steel barrels.

Nothing but economy and facility of construction warrant, it seems to me, any efforts to further contemplate experiments looking to its use.

The current opinion in French army circles, I am credibly informed, is that the Schultz construction is the best elaborated, and that which has the greatest power for endurance at the present writing. It is regarded as perfectly rational in theory, and experiments, as far as made, give weight to its claims.

In three or four months the 34-centimeter gun, it is stated, will be tested, and the experiments will be of much interest, especially as Captain Schultz desires that the pressures be run up to from 5,000 to 6,000 atmospheres.

Before closing this discussion on the Schultz wire gun, with its peculiar feature of separate and independent provisions for the tangential strain and the longitudinal breech strain, it is to be remarked that the advantages of the introduction of the latter principle in gun construction cannot be overlooked, and that every consideration warrants, if not demands, deep inquiry into the feasibility of its practical introduction in a system otherwise well digested to meet the other important requirements of maturely planned models. Increased strength must follow, and we would have, in the satisfactory introduction of this feature, an additional guarantee of the safe admission of greater strains than can be borne by ordinary constructions in which no provision is found for the separation of the two forces which now act together at the breech to rupture our guns.*

FRENCH ARMY ORDNANCE.

The broad features of construction of the army heavy ordnance are essentially those finding place in the naval guns, but the power deemed necessary for land purposes is much more limited, of course, than for marine and sea-coast uses; and hence, we find that a 24^{cm} gun is the highest type introduced into this branch of the service.†

The principal dimensions and other details regarding these guns are given in the following accompanying table, and a section of the all steel and the cast-iron gun, lined and fretted with steel of the same caliber (24^{cm}), will be found on Plates XXVIII and XXIX.

The steel guns are known as the Modèle de Bange. The body of the gun is composed of a tube of cast steel (tempered in oil and annealed), reinforced by frettes of puddled steel (tempered in oil or water). The breech frette is prolonged in rear of the base of the tube, forming a protection for the breech mechanism. The trunnions, except in field-guns, are hollow. Pieces of heavy caliber have carrying handles. The frette first placed in position abuts against a shoulder on the tube which prevents any forward sliding. (In the 180^{mm} and 240^{mm} guns, fretted all the way to the muzzle, it is the last cylindrical frette.)

The extremity of the chase is strengthened by a swell of the muzzle shaped like a band.

The seat of the breech mechanism has nearly the same diameter as the bore. The threads of small dimensions have a very short pitch. Their section is a rectangular isosceles triangle, the top of which is flattened. The cylindrical powder-chamber, with a diameter nearly the same as that of the bore, is connected with the latter by a truncated surface of short length where the grooves commence and against which the projectile abuts when seated home.

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* It is not intended to advocate in these general remarks the test of any plan in which the feature of separation of strains is subordinate or incidental to the plan for opening and closing the breech, but only to constructions which are solidly built up and to remain so; or, rather, are not susceptible of having or intended to have solidity broken to accommodate the mode selected for breach-loading.

† A marine model, 27^{cm}, cast iron, lined and fretted, finds place in the army ordnance table.

The ordinary screw fermeture, but with the de Bange gas-check, is used.

The 24^{cm} gun, model 1876, Plate XXIX, is a cast-iron gun similar in construction to the model of 1870 (naval pattern[*]) for the body of the gun, the fermeture differing, however, in the substituting of the de Bange gas-check, which is universally used, as before stated, in the land service of France. There are no novelties to point out in this construction other than those stated. The charges are 84 pounds of powder and 336 pounds weight of projectile for the 24^{cm} steel; and 62 pounds and 265 pounds for the 24^{cm} cast-iron and steel constructions. The former gives (it is reported from official sources) a velocity of 1,598 feet,[†] and a resulting muzzle-energy of 6,000 foot-tons.

THE DE BANGE FERMETURE.

A general description is only intended to be given of Colonel de Bange's mode of checking the escape of gas. Its general features are shown on Plate XXX, Fig. 1. It recommends itself prominently by effectiveness, its extreme simplicity, and its not requiring the surface of the bore to be recessed. Its success has warranted its adoption in the land service of France, and it is applied to all calibers.

The gas-check is composed of a fillet or collar made of a linen-cloth disk with a proper-sized circular hole, central with the circumference, set up into the form of a collar (see Plate XXX) to receive its filling. This latter consists of a mixture of two-thirds of shredded asbestos and one-third of mutton suet, packed into the collar, which is then closed and completed by a seam formed on the inside surface of the body. Any seams outside would be fatal to the construction. Considerable ingenuity has to be exercised in so forming the linen disk; and the present arrangement has been the result of considerable experiment before successful results were secured.

Two zinc or sheet-brass collars cover at top and bottom this collar (*a a*), and it is placed, in addition with two copper rings (*d d*), between the rondelle (*b b*) and the face of the fermeture, a tail or rod (*e*) to the rondelle passing through the fermeture and being keyed to keep the system in position in the block. The vent, lined with copper, finds place in the axis of the breech-block, thus affording central-fire.[‡]

It may be of interest to allude now, while on the subject of French army ordnance, to some views held in France regarding chambering, and which, I presume, have had their weight in causing this feature to be practically dispensed with in the present land constructions.

I am informed as follows:

> The maximum pressure in the bore (supposing the powder to be progressive enough to render the local pressures arising from wave action noticeable), corresponds, about to the position of the projectile, where it has moved one and a half calibers in the bore. Supposing the sketch to represent a chamber of the description referred to, it is easy to see that the transverse strain on the fiber A B B′, will vary very rapidly between B and c; this effect taking place also on the other fibers of the metal, tends to break them. In using Lanie's formulas, both for guns either of a single block or built up, it is easy to see the shearing effect which this has a tendency to produce, especially if the *longitudinal* strain of the discharge is taken by the internal tube as in the French guns.

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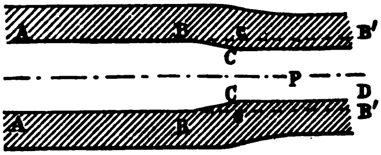
[*] Cannon up to 29^{cm}, naval pattern, are also used in the French land service.

[†] See Gadand.

[‡] For additional remarks on this check, see page 255.

1st. In this case, the tube so disposed, is in *excellent condition to give way* if the enlargement of the chamber is great. Adding to this the effect of the vibrations which are broken between B and c, it seems that any excessive enlargement of the chamber should be avoided.



2d. The rush of gas along the shoulder B c, produces erosive and destructive effects of a bad character on this part of the gun, whenever the core B c is greatly pronounced, which is easily accounted for if the *dynamic* action of the gas is taken in consideration.

If the powder is also burning, and part of it is projected forward as the projectile just begins to move (which can happen especially if the ignition comes from the rear), the hard burning cake forced through the narrow pass B c, spoils the bore at this part and roughs it promptly. This occasions much fouling and difficulties in loading, besides the wear and tear of the gun. Barrels made of soft, or wrought iron, are more exposed to these effects than those made of tough material. Of course the chamber must always be larger than the bore at the bottom of the rifling; but it is better to reduce this enlargement as much as possible.

Regarding the tendencies of the developments in France, in artillery, I am further informed—

1st. To make *entirely* distinct parts of the gun bear the longitudinal and transversal strains.

2d. To study powders appropriate to each nature of gun, and allowing to bring up the density of the charge to nearly 1 (that is firing with full chambers), without excess of pressure. Of course, this part of the question is not entirely solved yet for the different guns; but the present experience gives us a right to hope that this result will be promptly attainable.

3d. The bringing up of the velocity to 550 meters and over, and of the weight of the projectile to 3½ to 4 times that of the spherical solid shot.

In reference to the cost of the different constructions, I append herewith[*] in a foot-note, some recent information on this point, kindly furnished by the Messrs. B. B. Hotchkiss & Co., of Paris.

The "Modèle de Bange," 24^{cm}, it will be seen on an inspection of Plate XXVIII, is a well-proportioned gun of extreme simplicity in design; the only part of any moment in a constructive point of view being the body. The weight of the entire gun is only 13.75 tons. The frettes, trunnion-bands, and other parts outside of the core, weigh 7 tons. All these parts are small in size. hence readily handled, and the rough-turned steel forgings from steel works being obtained, the only prominent part as before stated being the body. The assembling and finishing of the gun is simple work, and within the capacity of ordinary machinery and appliances.

The only question is if it has sufficient longitudinal (breech) strength. However this may be, it is a construction well worthy of consideration.

The following table gives the charge, &c., of the more important guns of the French service, and shows their relative energies per ton of metal:

Caliber.	Charge.	Projectile.	Initial velocity.	Muzzle energy.	Energy per ton of metal.	Kind.
	Lbs.	*Lbs.*	*Feet.*	*Foot-tons.*		
42 centimeters	617.3	1,726	1,738	36,628	485.8	Navy,
37 centimeters	545.6	1,177	1,955	31,180	415.7	
34 centimeters	462.	924	1,955	24,482	415.	
27 centimeters	237.6	464	1,955	12,294	396.6	Navy.
34 centimeters	440.	935	1,950	24,647	493.	Schultz.
24 centimeters	84.	336	1,600	6,033	430.	Army steel.

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[*] Krupp, 51 to 60 cents per pound; Whitworth, 38 cents per pound; Woolwich, 30¼ cents per pound; and 48 cents per pound for 24^{cm} steel land-service ordnance of France.

It will be seen that the views of the French engineers on construction are about the same as those now existing amongst English constructors, and that they are striving to reach results in power combined with lightness, which are gradually rendering *imperative* the ultimate discarding *in toto* of cast iron in their models.

A brief summary may here be added in closing this report on French heavy ordnance.

1st. A long and patient test of, and an experience (in breech-loading systems) with steel-fretted cast iron has resulted in failure and abandonment.

2d. The adoption of the model of 1870, cast-iron hooped and tubed, has given good results, warranting the introduction of this type in service.

3d. That with the development of the steel interests of France, the French authorities are not satisfied with cast iron entering into their constructions, and are resorting to steel entirely, and that they contemplate the disuse of the former.

4th. That wire guns are being persistently experimented with, and are looked to as promising to be introduced as the guns of the future.

5th. That constructions looking to the "division of strains" are regarded as the probable solutions of the dangers arising from the combination at the breech of the longitudinal (breech) and tangential (breech) stresses; and that the Schultz plan is preferred.

6th. That a new, simple, and an apparently effective fermeture, other than the Broadwell, has been tested with success, approved and adopted at least in the land service of France. This fermeture is known as the *de Bange*.

7th. The undoubted tendency in France, and, as before mentioned, in England and in other countries, is to resort to steel constructions for ordnance. This leaves me to remark that the use of this metal in some form or other—as developments in production in our country may decide—is a foregone conclusion; and that some plan looking to its speedy, *practical* introduction in our fabrications cannot too soon be inaugurated; and as a sequence to this view, I cannot too strongly suggest to the department the consideration of the question whether it would not be sound policy for it to institute at once, through its own resources, a thorough inquiry into the present condition of our steel manufactures, ascertain their wants in plant, and other facilities for the attainment of the production of a proper grade of this material for reliable gun constructions; all with a view of presenting to the governing and proper authorities the plain necessities which surround the case, and which must be met to enable us to develop the proper material for ordnance, and to cope in this respect with the modern armaments of modern civilization.

It is useless to attempt to engage capital for these developments, unless some guarantee for at least return of outlays on the part of manufacturers are reasonably assured; and if no *systematized* efforts on the part of the government looking to inaugurating a prudent and gradual development of manufactures in this direction, and under government patronage, are set on foot, we will remain, regarding the question of ordnance, as we are now, tied mostly to the present resources of the United States, and likely to remain so for years to come.

The limits imposed by too great a deference to the idea of restricting our efforts in ordnance advancements to our own *immediate* resources especially in our experiments is disastrous, if not fatal, to any rapid progress.

In the past, our experience has been that we have been more or less crippled by our field (experimental) for developments being narrowed by too close an adherence to this principle. Partly under this influence we will in all likelihood start with a system of cast iron strengthened with steel inside and out, a system now abandoned or doomed to abandonment in the near future, even by the few prominent nations who have heretofore depended upon its use.

That necessity in a great measure will now drive us to this cannot be gainsaid, but the "*present resources of our country*" should not bind us to the perpetuation of an inferior system, nor one day longer than the development of steel *models* and steel products will release us. The use of steel parts from abroad for experimental models, and it may be for some guns, will be a necessity for the present if rapid advancement is desired, and it would be useless to expect a prompt introduction of constructions now beyond our own means of fabrication if we do not avail ourselves (at least for experimental guns) of the present products of more advanced nations in steel manufacture, and also of their more advanced experience.

Only by some practical plan for the development of our own steel interests can we escape the condition of being a rich and powerful nation with our best armament of a secondary character, and one based on the use of a metal thoroughly tested by other countries, and which tests have led to its abandonment for the purposes of their *superior* constructions.

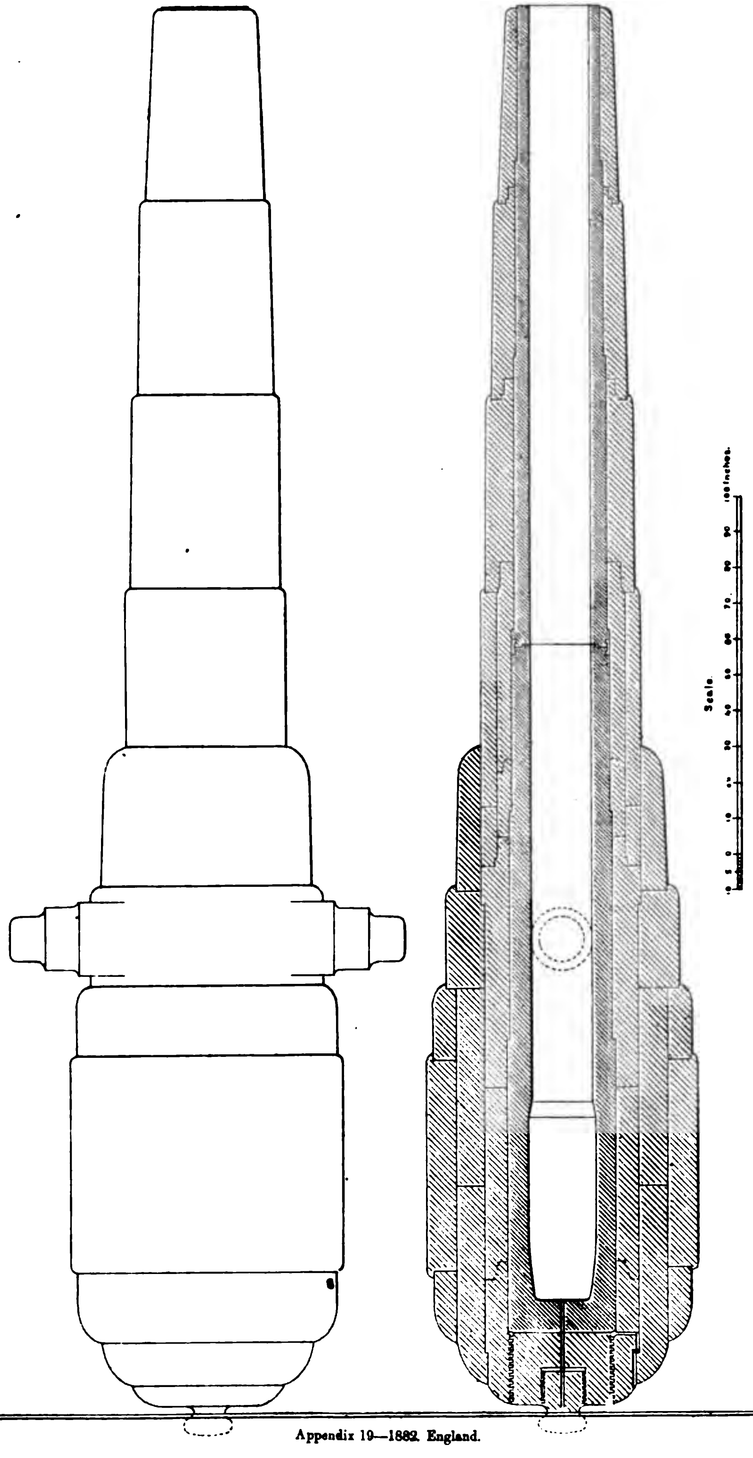
These remarks are, of course, only applicable to ordnance of the most formidable character, and not to guns for secondary uses where, low power only being required, cast iron may play a part in their fabrication.

From this report on French heavy ordnance it may be germane to state here, that, from the fair standing of the model of 1870, we can reasonably hope to secure a judicious solution of the problem of how to model the plans for the four 12-inch rifles now under contract for the service of the United States by a consideration of the French construction.

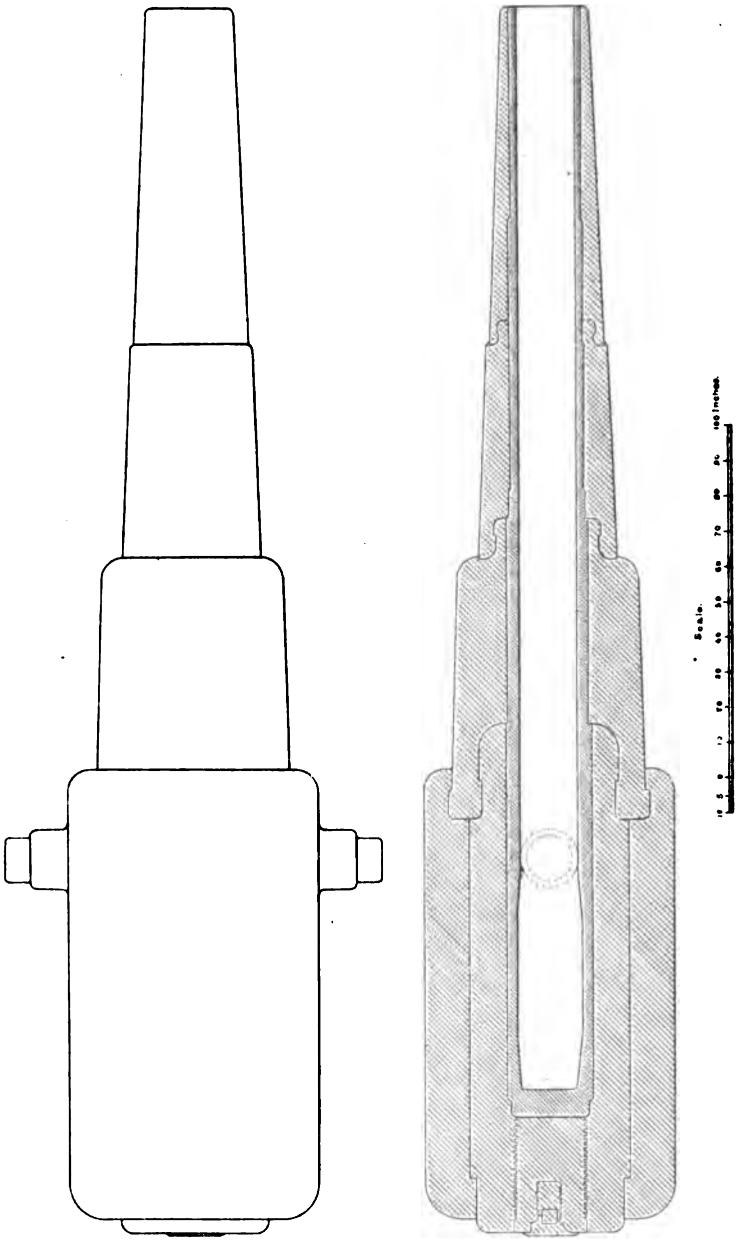
One of these guns would afford an experimental one, if any after the French model should be required under the action of the Board on Heavy Ordnance and Projectiles convened under act of Congress approved March 3, 1881.

PLATE I.

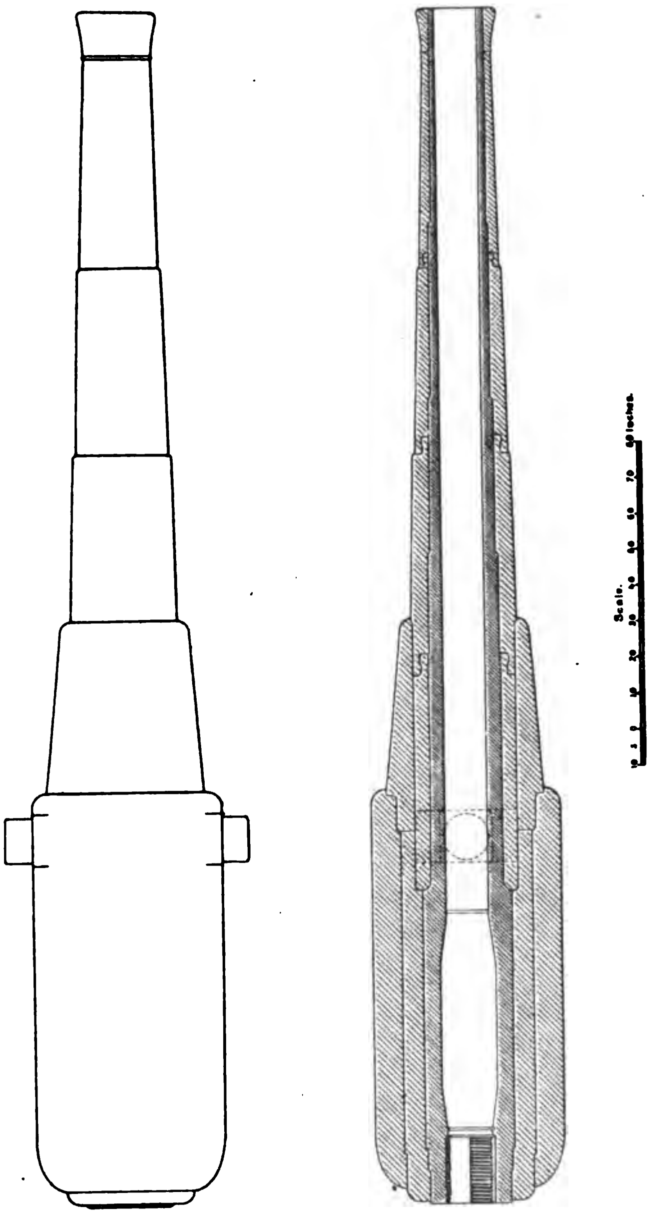
17·72 INCH ARMSTRONG GUN – 100 TON.



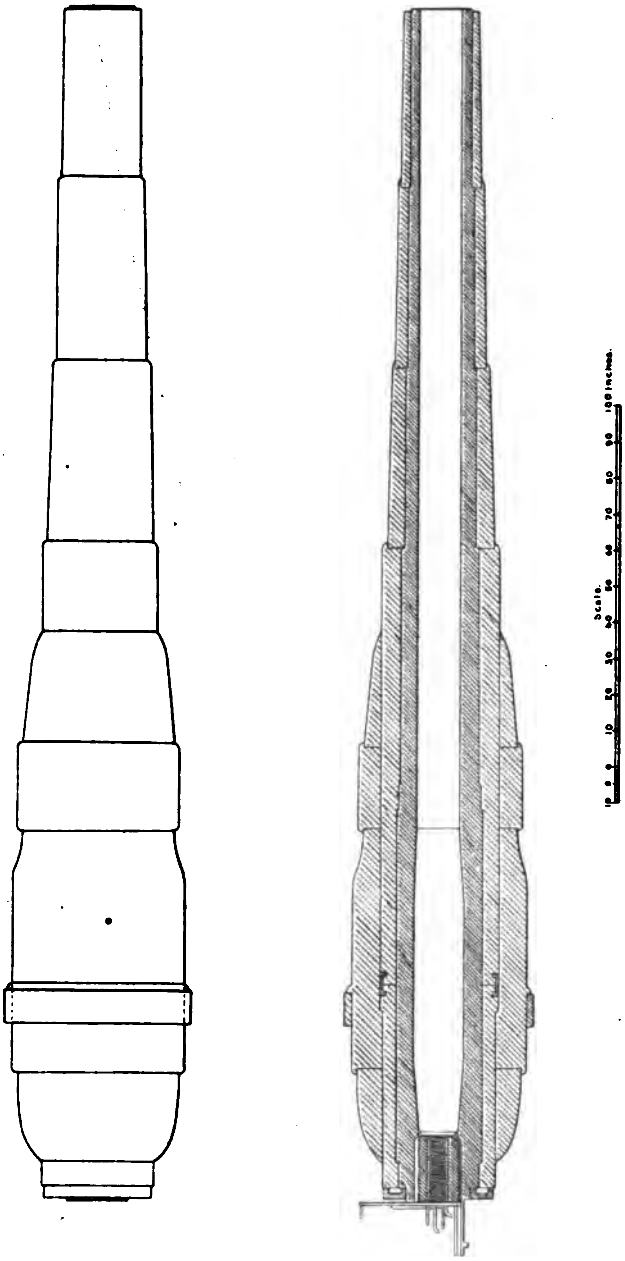
16 INCH WOOLWICH GUN – 80 TON.



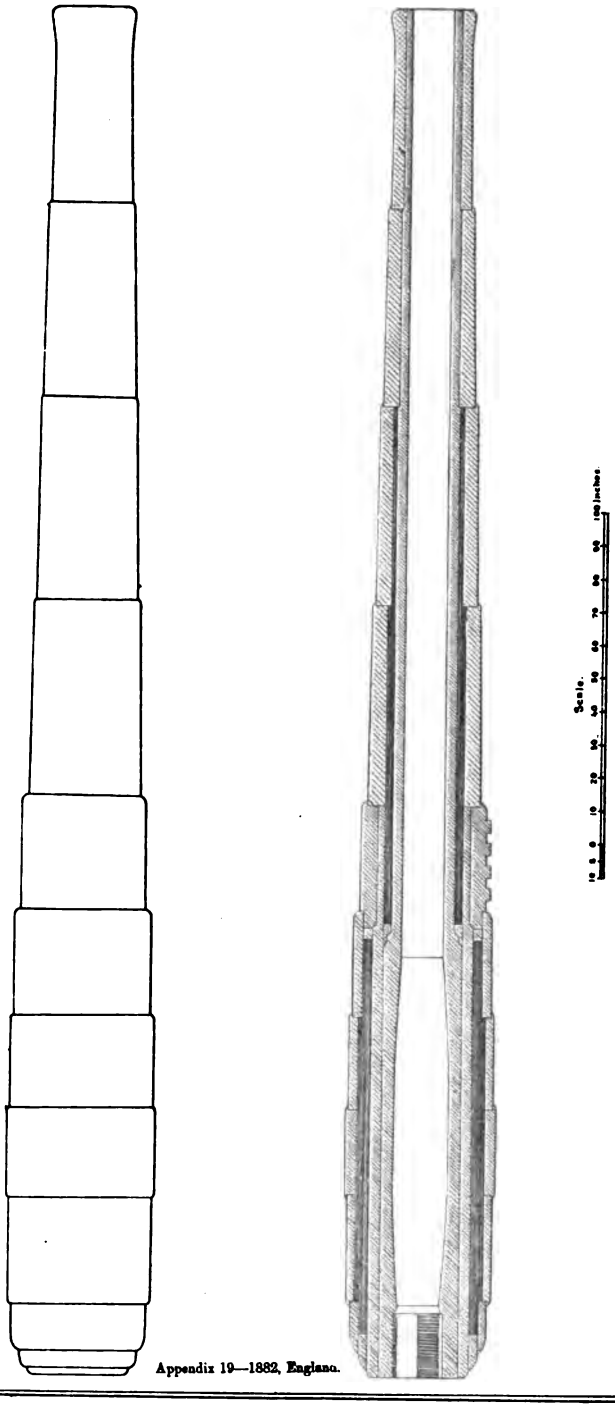
12 INCH B. L. WOOLWICH GUN – 43 TON.



12 INCH B. L. ARMSTRONG GUN – 43 TON.

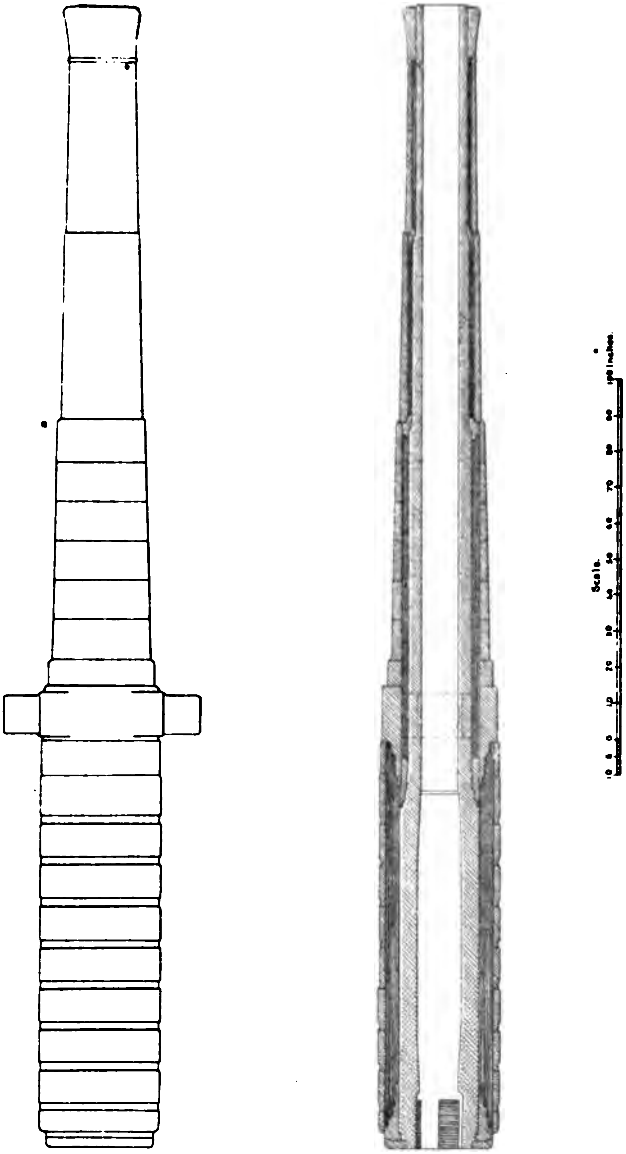


13 INCH B. L. ARMSTRONG WIRE GUN – 44 TON.



Appendix 19—1882, England.

10·236 INCH B.L. ARMSTRONG WIRE GUN–21 TON.

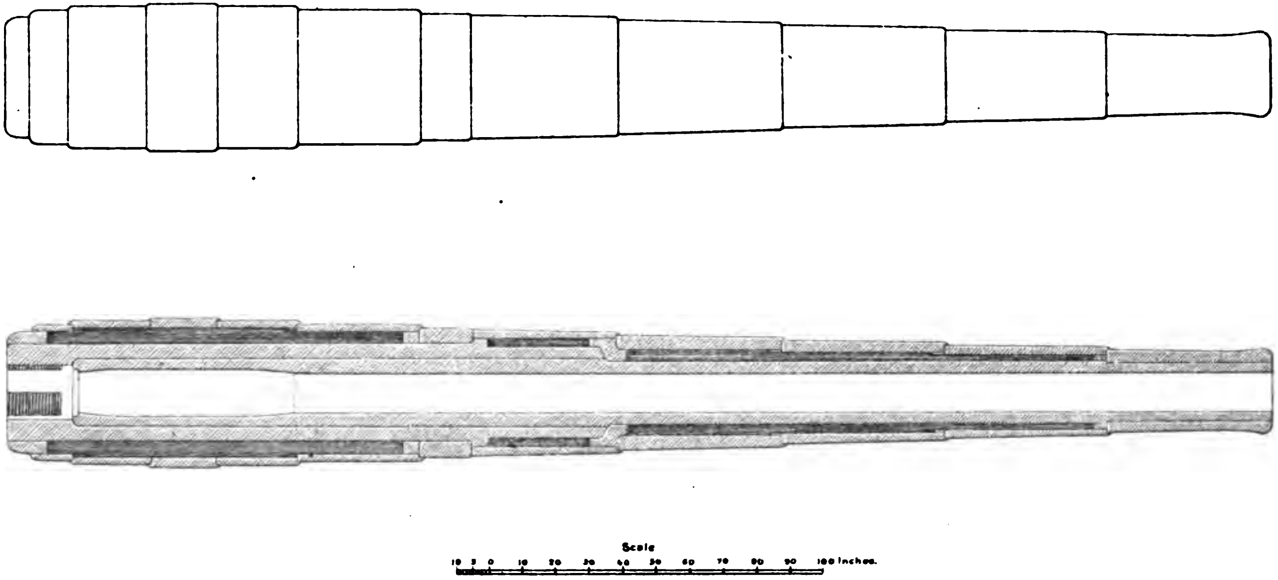


Appendix 19—1882, England.

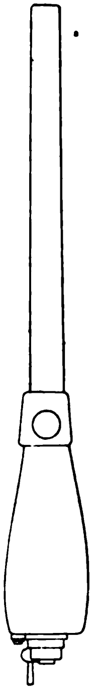
PLATE VII.

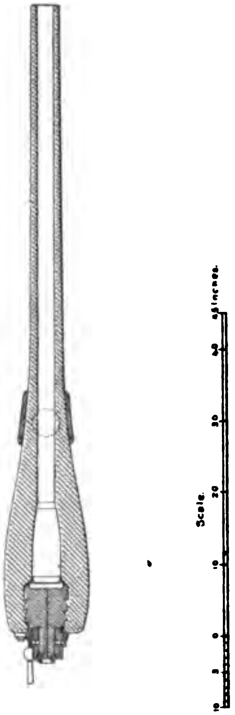
SKETCH SHOWING A 12 INCH B.L. ARMSTRONG WIRE GUN MODIFIED BY THE INTRODUCTION OF A THIN INTERIOR STEEL TUBE.

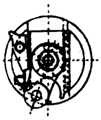
40 TON. (APPROX.)



9 PDR. WHITWORTH GUN.







PLAN OF ELSWICK ORDNANCE WORKS.

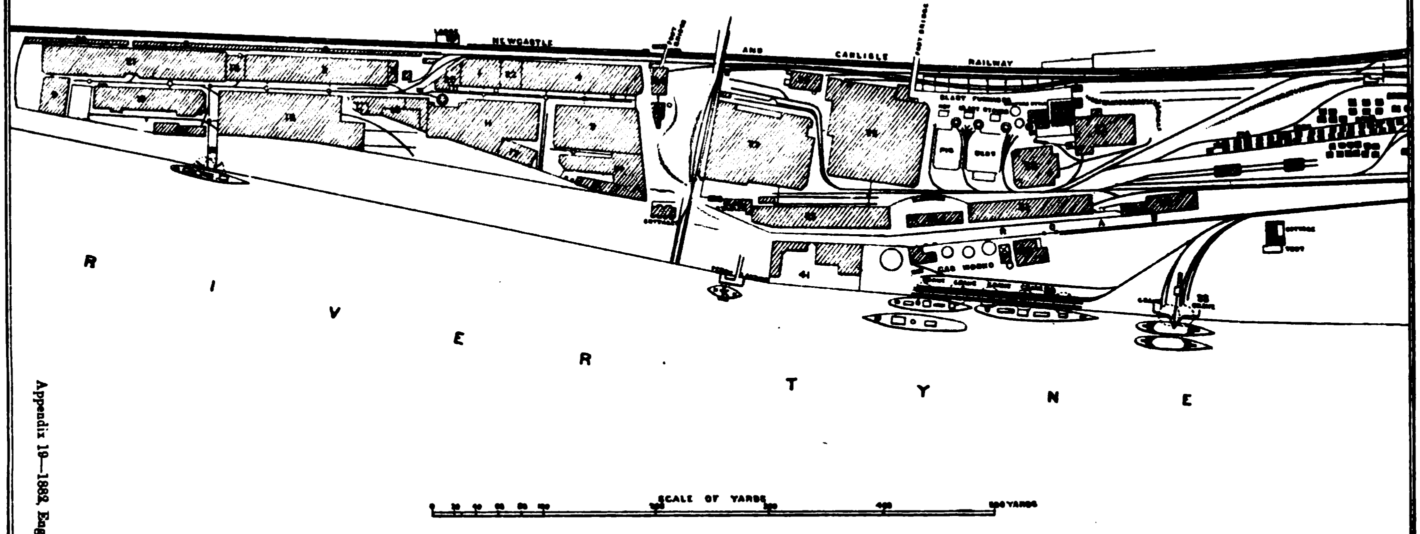
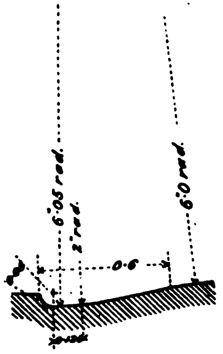


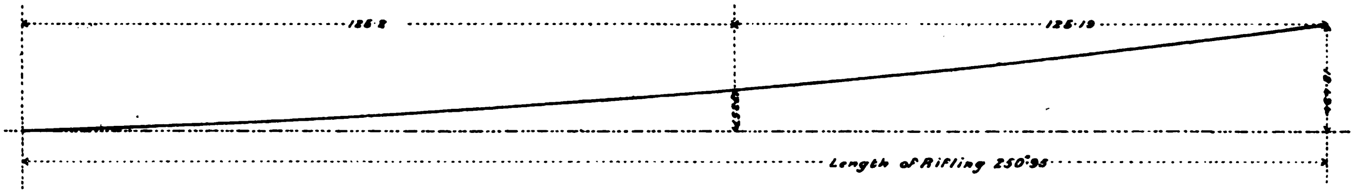
PLATE X.

12 INCH B. L. WOOLWICH GUN – 43 TON.

— DETAILS OF RIFLING —



RIFLING.— An increasing twist from one turn in 120 calibres at Breech to one turn in 35 calibres at 125·2 inches from Breech, the remaining 125·19 inches being a uniform twist of one turn in 35 calibres.   Nº of Grooves 48.



Appendix 19—1882, England

ARMSTRONG WIRE GUN

Fig. 5.

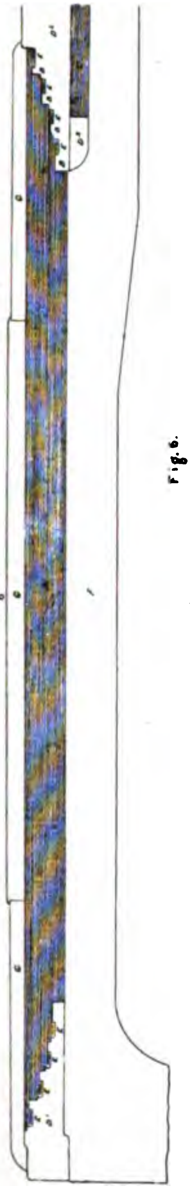


Fig. 6.

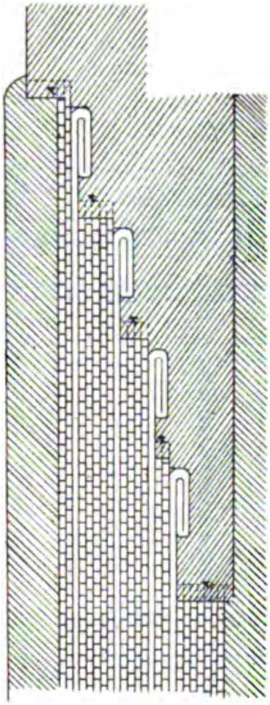


Fig. 9.

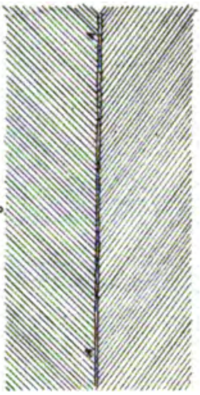


Fig. 8.

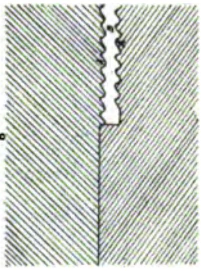
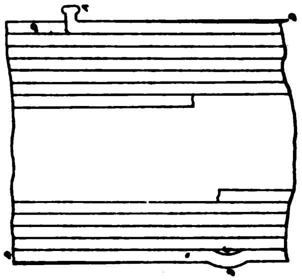


Fig. 7.



ARMSTRONG WIRE GUN.

FIG. 1.

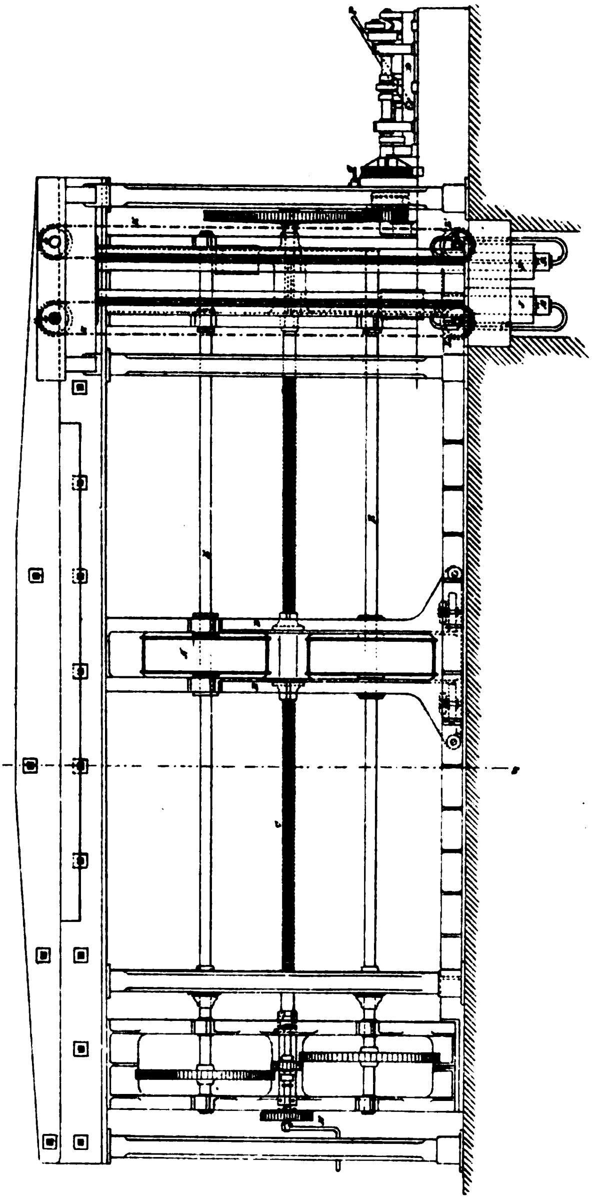
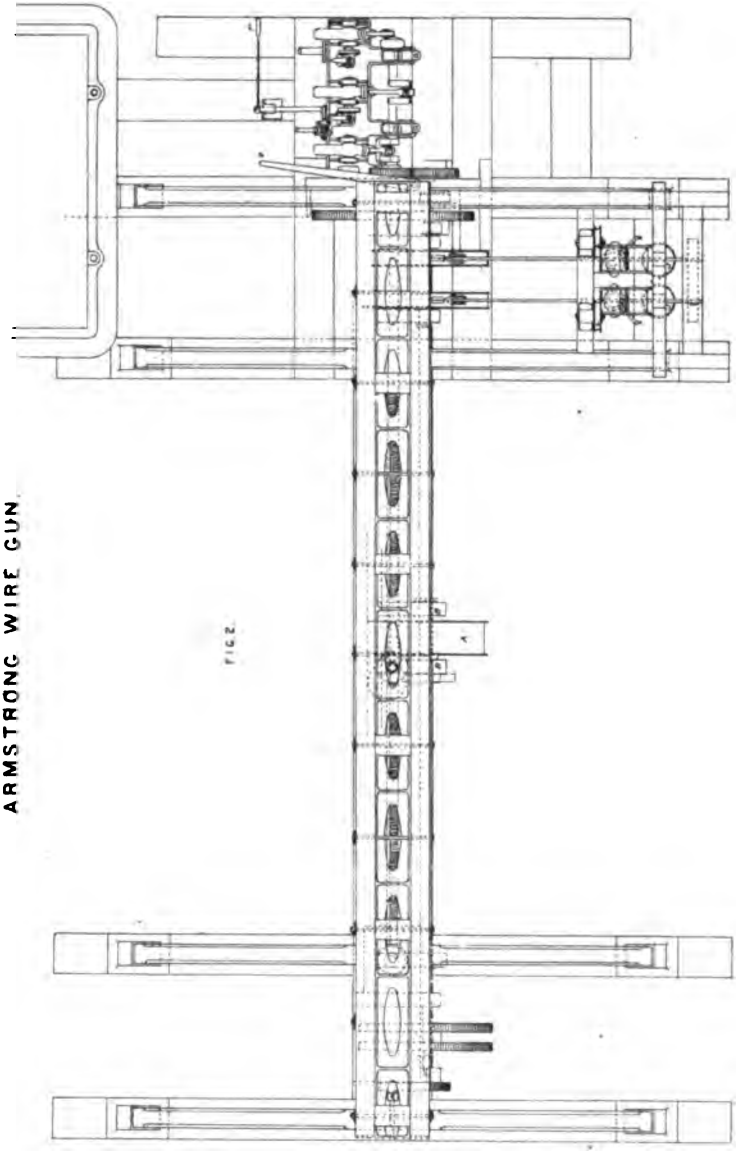


PLATE XIII.

ARMSTRONG WIRE GUN

FIG. 2.



Appendix 19—1882, England.

PLATE XIV.

ARMSTRONG WIRE GUN.

FIG. 3.

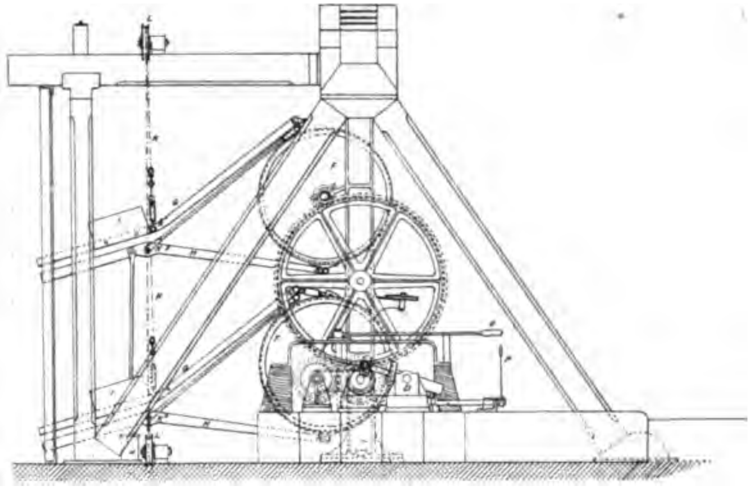


FIG. 4.

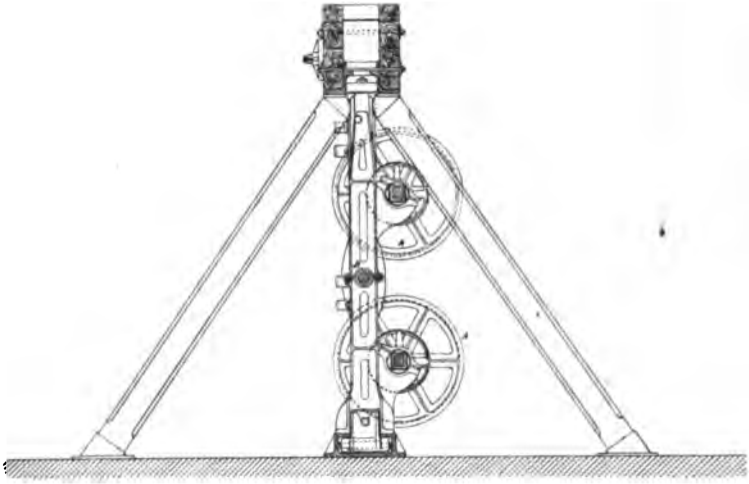
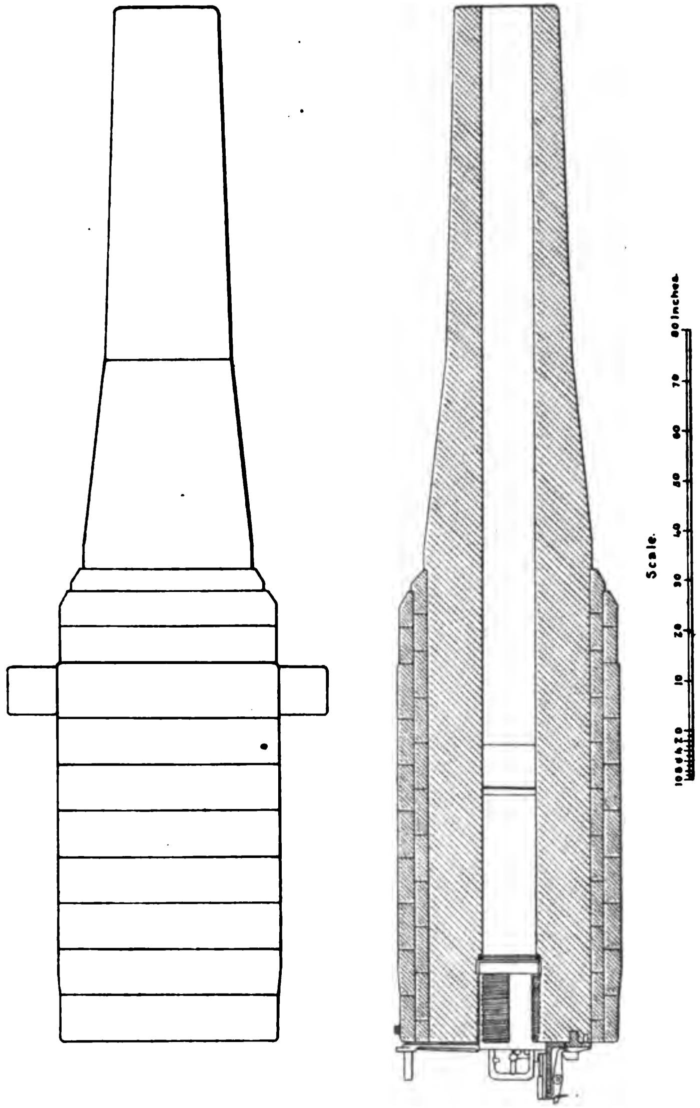


PLATE XV.

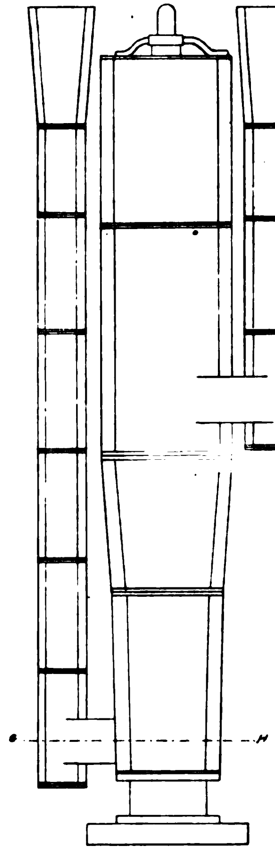
27 c/m B. L. RIFLE — MODEL 1864 — NAVY.



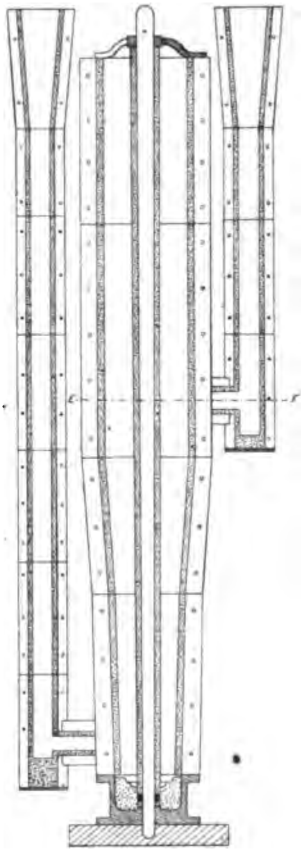
Appendix 19—1882, France.

PLATE XVI.

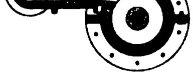
FLASK FOR CASTING GUNS AT RUELLE.



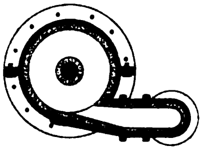
Side View



Vertical Section



Section on G.H.



Section on E.F.

32 c/m B.L. RIFLE — MODEL 1870 — NAVY.

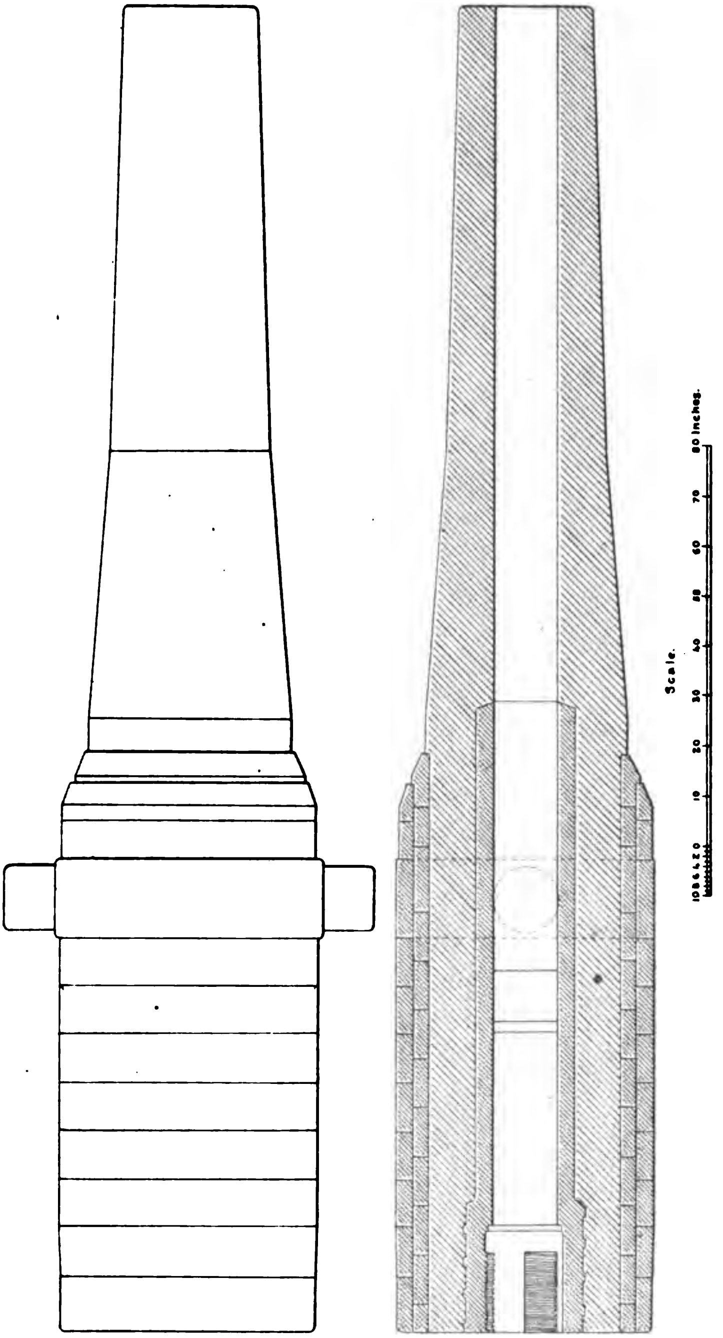


PLATE XVIII.

FURNACE FOR HEATING GUNS FOR INSERTION OF STEEL TUBES.

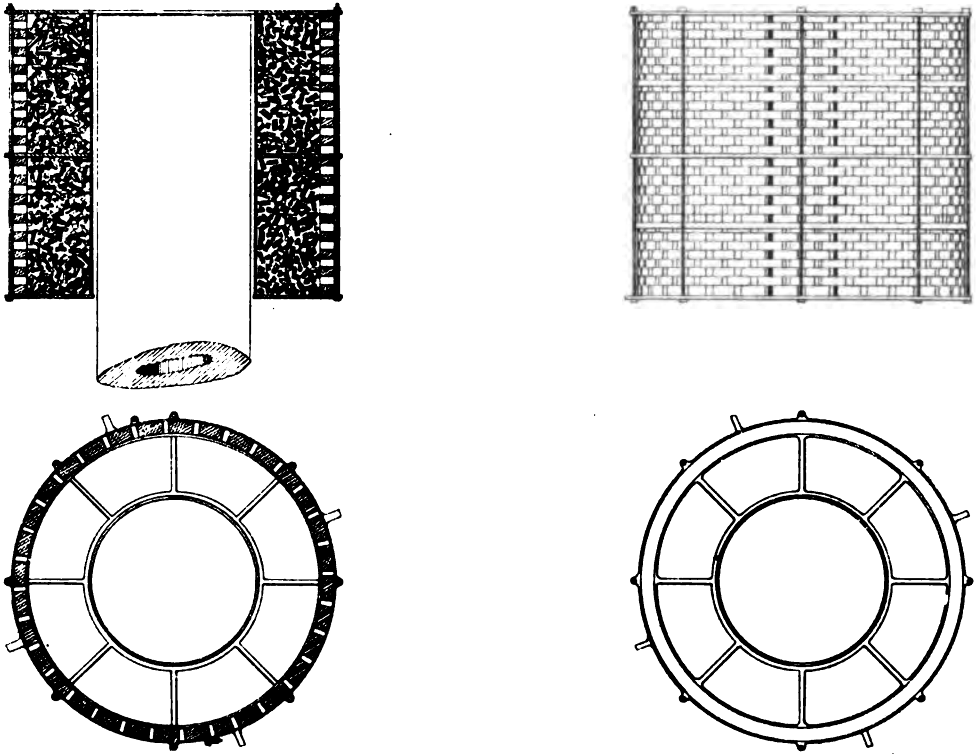
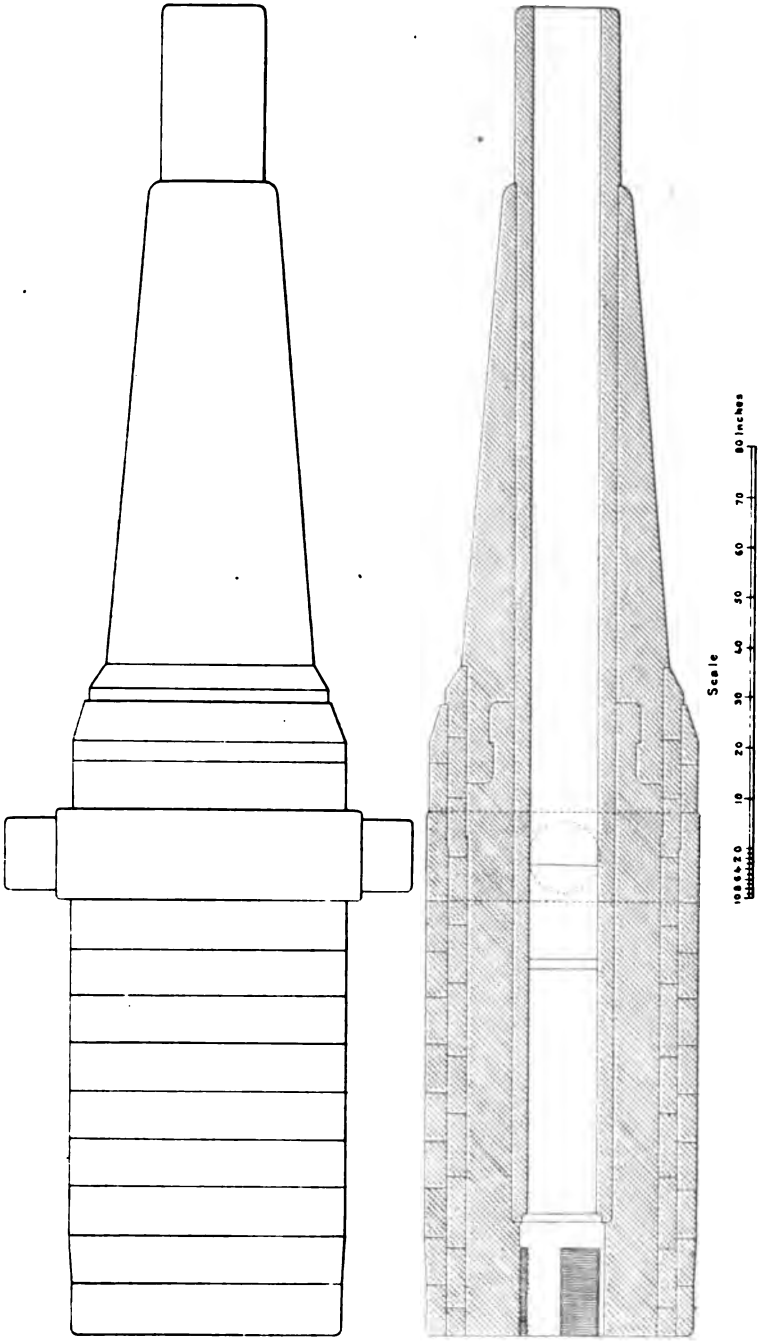


PLATE XIX.

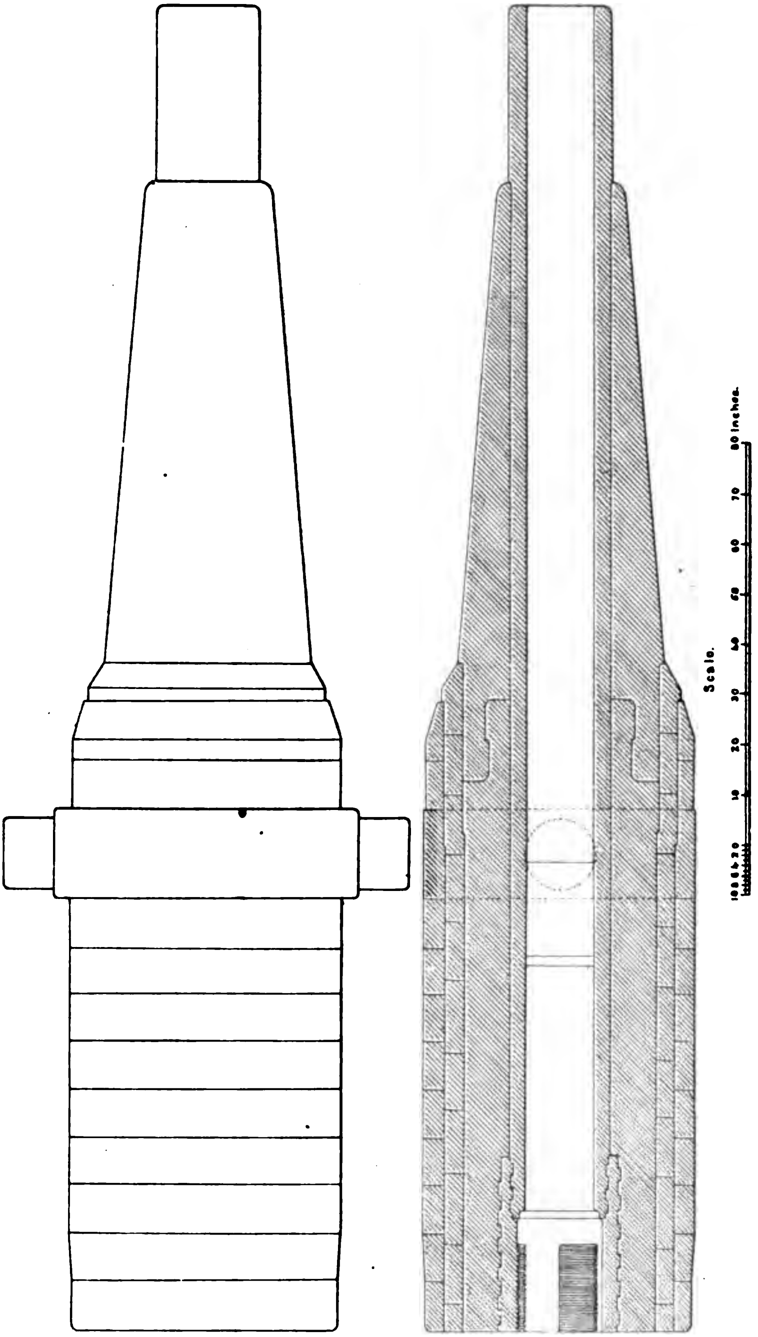
34 c/m B. L. STEEL RIFLE — MODEL 1875 — NAVY.



Appendix 19—1882, France.

PLATE XX.

34 c/m B. L. STEEL RIFLE — MODEL 1875 — NAVY.



Appendix 19—1882, France.

SKETCH OF PROPOSED 9 INCH WIRE WRAPPED B. L. STEEL RIFLE.

AFTER THE PLAN OF SCHULTZ FOR SECURING A DIVISION OF STRAINS.

WEIGHT 18 TONS — LENGTH OF BORE 30 CALS.

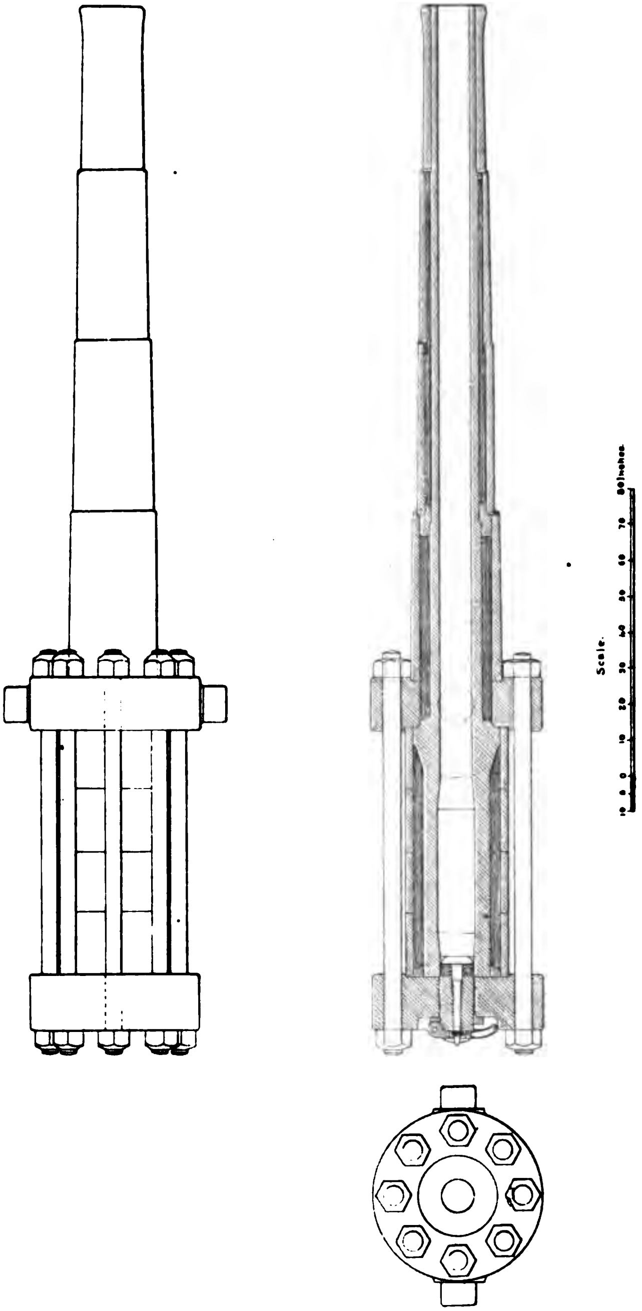
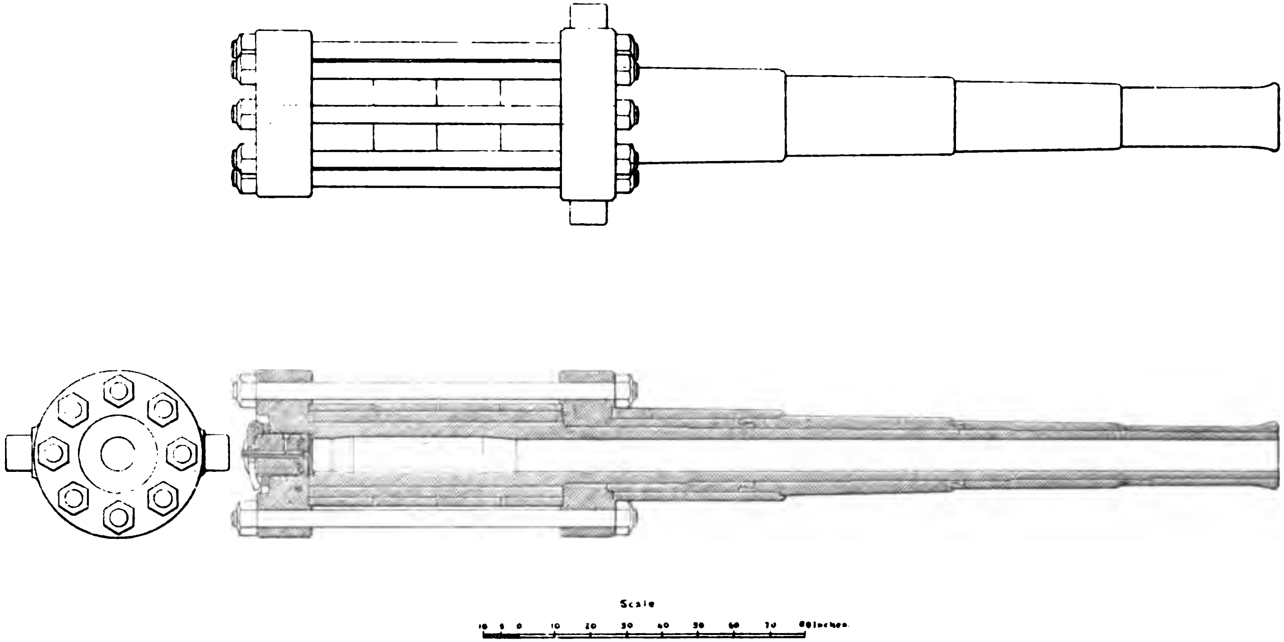


PLATE XXII.

SKETCH OF PROPOSED 9 INCH B. L. STEEL RIFLE.

AFTER THE PLAN OF SCHULTZ FOR SECURING A DIVISION OF STRAINS

WEIGHT 18 TONS — LENGTH OF BORE 30 CALS.



Appendix 19—1882, France.

METHODS OF SECURING ENDS OF WIRE.

Fig. V

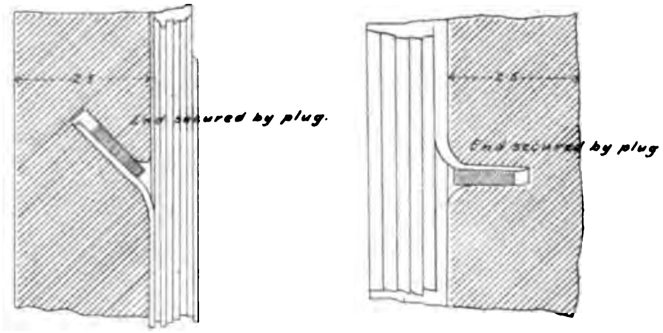
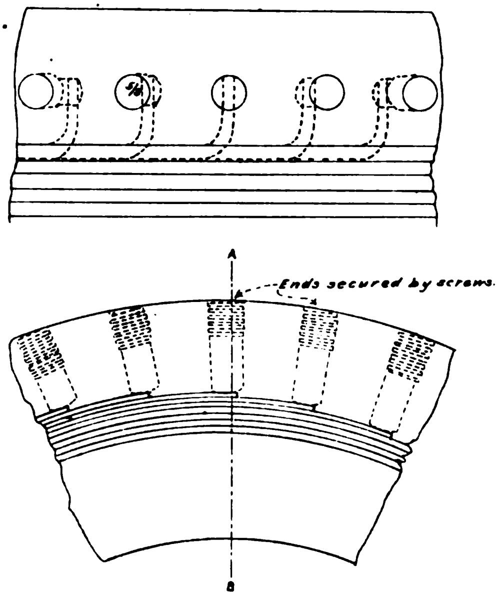
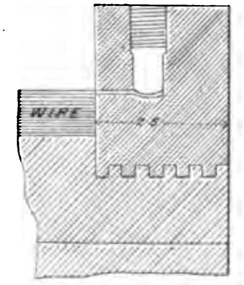


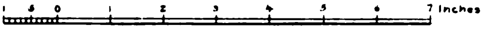
Fig. VI



Section through A.B.



Scale



Appendix 10 · 1882, France.

CYLINDERS AS PREPARED FOR RECIEVING WIRE.

Fig. I.

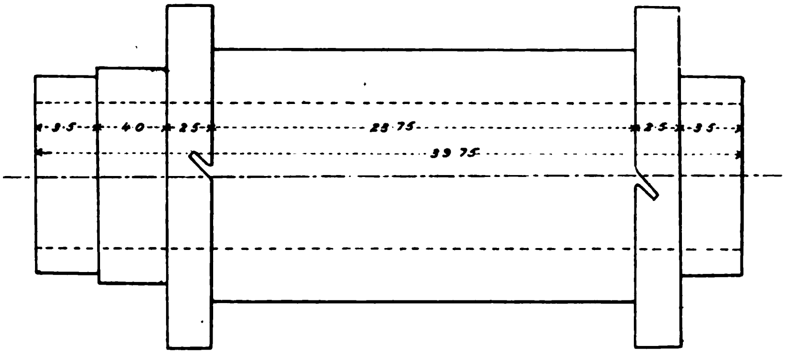
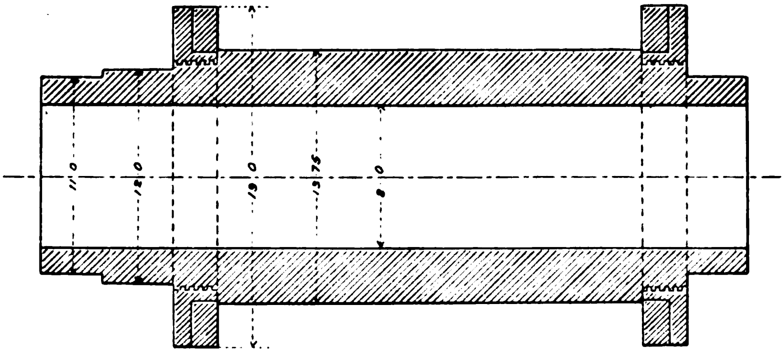
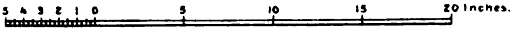


Fig. II.



Scale.



TEST CYLINDERS FOR COMPARATIVE TRIALS OF GUN MATERIAL AS PREPARED FOR FIRING.

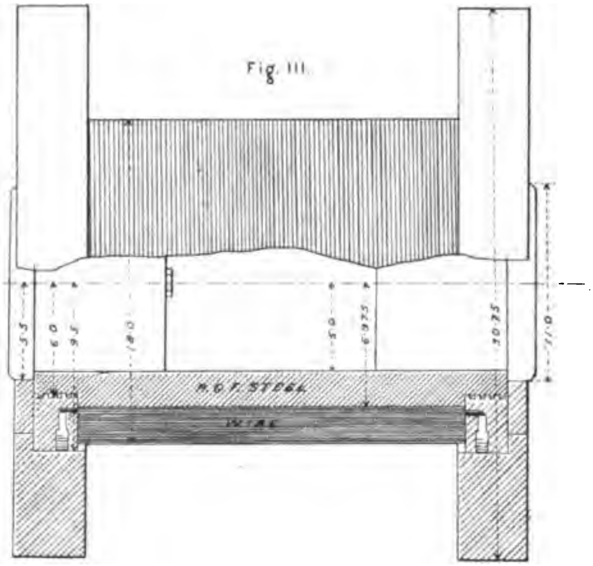


Fig. III.

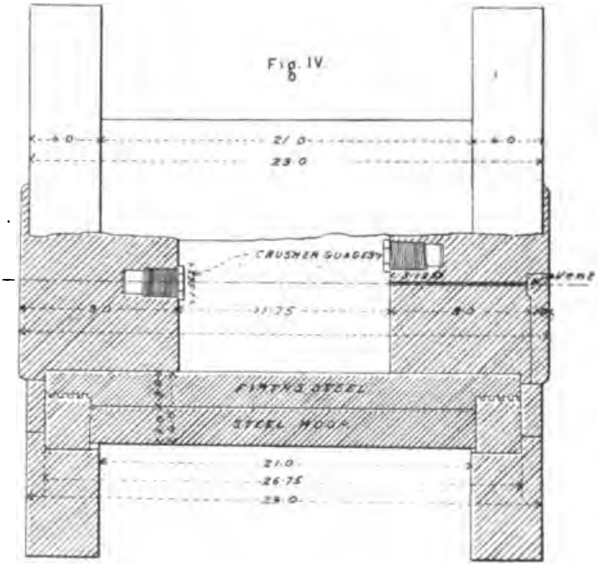


Fig. IV.

Scale

PLATE XXVI.

SCHULTZ WIRE GUN

Fig. 1.

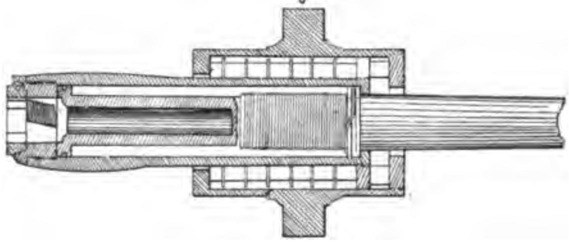


Fig. 2.

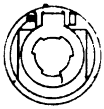


Fig. 12.

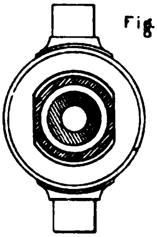


Fig. 10.

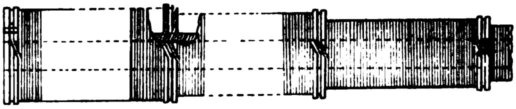
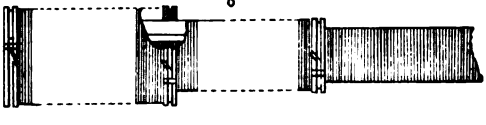


Fig. 11.



Appendix 19—1882, France.

SCHULTZ WIRE GUN

Fig. 3.

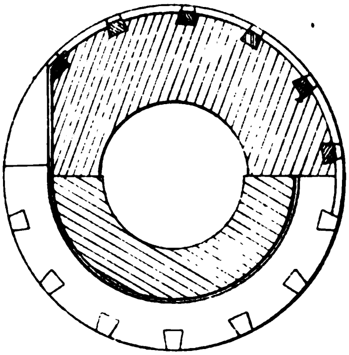


Fig. 4.

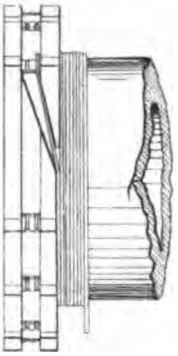


Fig. 5.

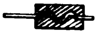


Fig. 6.

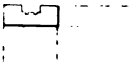


Fig. 7.

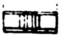


Fig. 8.

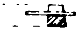


Fig. 9.

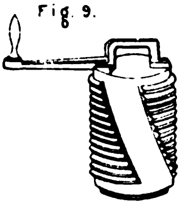
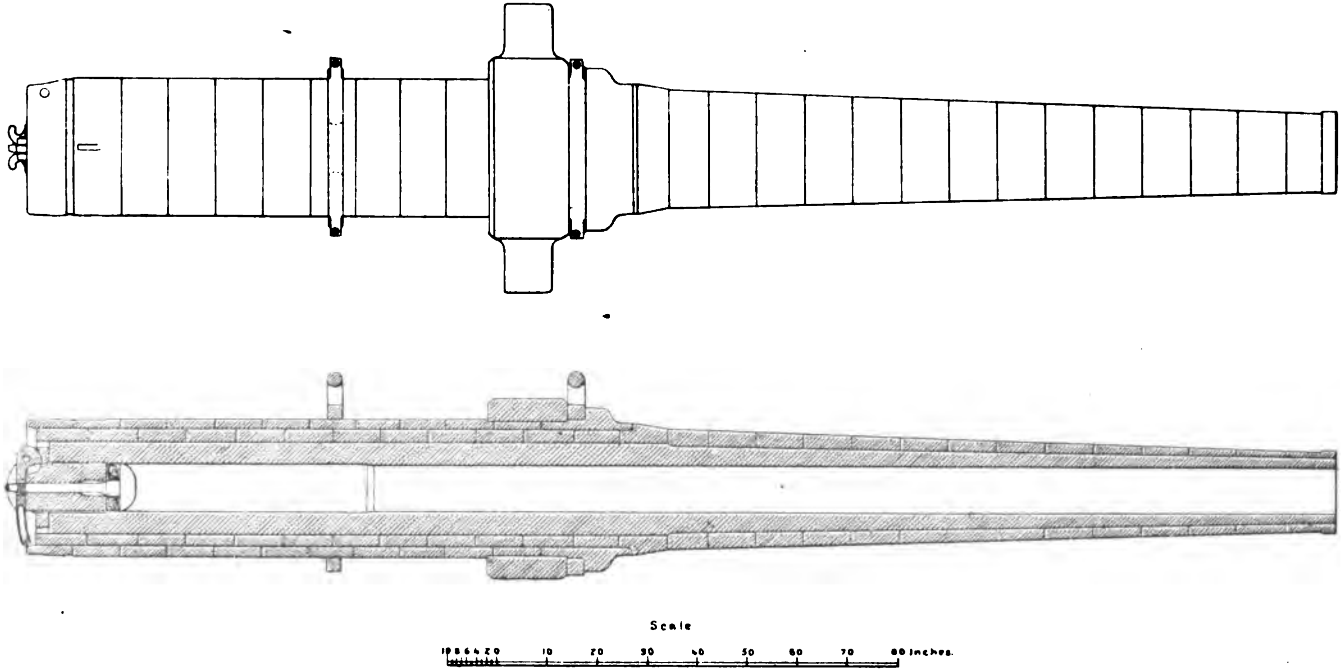


PLATE. XXVIII.

24 c/m B. L. STEEL RIFLE — MODEL 1876 — ARMY.



Appendix 19 — 1882 France.

PLATE XXIX.

24 c/m B. L. RIFLE — MODEL 1876 — ARMY.

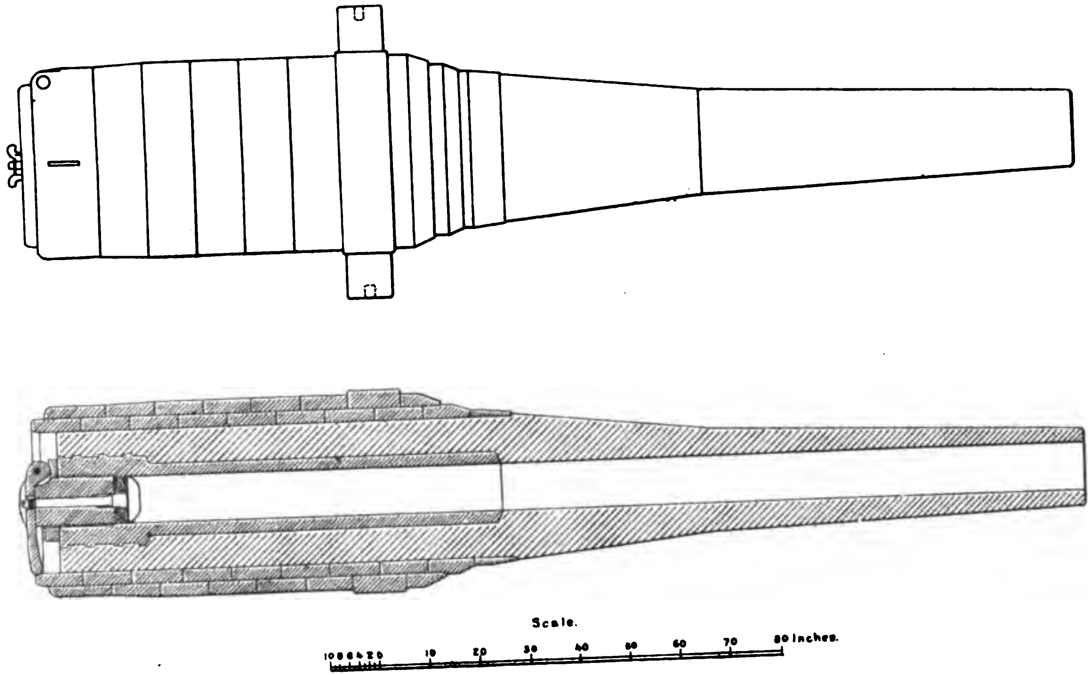


PLATE XXX.

FERMETURE DEBANGE

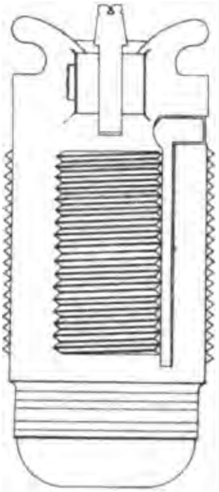
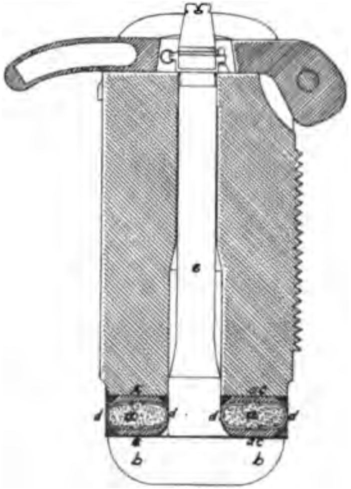
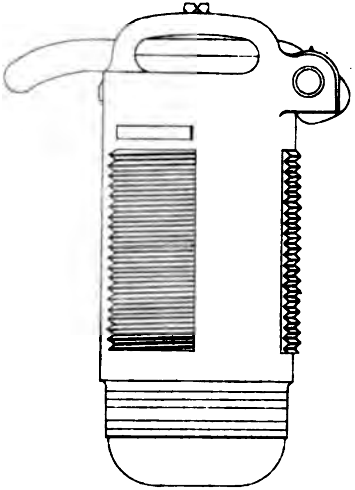


Fig. 1.





APPENDIX 20.

REPORTS ON THE INSPECTION OF PROJECTILES.

BY LIEUT. HENRY D. BORUP, ORDNANCE DEPARTMENT.

THE SOUTH BOSTON FOUNDRY,
Boston, July 29, 1882.

SIR: I have the honor to transmit herewith the inspection report and certificate of inspection, together with a table showing number cast daily, and the tenacity, density, &c., of three hundred 4.2-inch Butler solid shot, ordered under date of June 5, 1882. As nothing of any particular interest occurred during the fabrication, I have not written any supplementary report.

Very respectfully, your obedient servant,
HENRY D. BORUP,
Lieutenant of Ordnance, Inspector.

The CHIEF OF ORDNANCE,
Washington, D. C.

INSPECTION SERVICE, UNITED STATES ORDNANCE DEPARTMENT.

CLASS 4.—PROJECTILES FOR 4".2-INCH M. L. RIFLED GUNS.

Inspection report of 4.2-inch ogival-headed Butler shot made for the United States Ordnance Department by the South Boston Iron Company, at South Boston foundry, under order of Brig. Gen. S. V. Benét, dated June 5, 1882.

[The time was extended thirty days, June 30, 1882.]

Subject of measurement.	Prescribed dimensions.	Allowed variations.
Projectile:		
Length of cylindrical portion of body	11"	+2 per cent.
Length of head	4".75	−2 per cent.
Length of base for sabot	1".10	±0".05
Total length of projectile	11"	1 per cent.
Diameter of cylindrical portion	4".16	±0".01
Diameter of base over threads	2".95	....
Radius of head	6".40	±0".01
Sabot:		
Height of sabot	1".10	±0".01
Exterior diameter of sabot	4".16	±0".01
Interior diameter of sabot	2".95	±0".01
Maximum thickness of outer lip	".15	±0".01
Minimum thickness of outer lip	".15	±0".01
Depth of cannelure	0".6	±0".01
Maximum width	".22	±0".01
Weight of sabot and projectile ... pounds	30	±.015

Number of 4.2-inch Butler solid shot examined	318
Number rejected for erroneous dimensions of head	2
Number rejected for defects in material or finish	16
Total number rejected	18
Total number accepted	300
Weight of heaviest ones accepted ... lbs.	$28\frac{9}{16}$
Weight of lightest one accepted ... do.	$28\frac{1}{16}$
Weight of total number accepted ... do.	8,549
Mean weight of projectile ... do.	$28\frac{7}{16}$

Number of sabots examined	335
Number of sabots rejected for erroneous dimensions	9
Number of sabots rejected for defects in material or finish	26
Total number of sabots rejected	35
Number of sabots accepted	800
Weight of total number accepted ... lbs.	567
Mean weight of sabot ... do.	$1\frac{14}{16}$
Weight of total number of shot and sabots accepted ... lbs.	9,116

Physical properties.

Actual mean density	pounds..	7.1813
Tenacity:		
Prescribed	do....	23,000
Actual mean	do....	26,877
Allowed variations	per cent..	—3

REMARKS.—The Quartermaster's Department have been requested to transport the projectiles to Maj. Clifton Comly, West Point, N. Y.

I certify that I have carefully inspected the above-noted projectiles, and that they conform to the dimensions prescribed within the variations allowed; and, further, that the terms of the order as to material and workmanship have been complied with in their manufacture.

HENRY D. BORUP,
Lieutenant of Ordnance, Inspector.

Date of inspection, *July* 29, 1882.

Date. 1882.		No. of casting.	No. of projectiles cast.	Kind of iron.	Amount of each.	Kind of furnace.	Tenacity.	Specific gravity.
June	15	1	4	No. 1 Chatham	3,250	Reverberatory	27,640	7.1426
				No. 2 Chatham	3,950			
				No. 3 Chatham	4,100			
				Remelted	3,700			
	20	2	6	Same		do	25,988	7.1592
	21	3	6	do		do	29,522	7.2187
	22	4	6	do		do	34,167	7.2856
	23	5	6	do		do	27,825	7.2092
	24	6	11	do		do	24,058	7.1180
	26	7	10	do		do	28,579	7.1601
	27	8	12	do		do	34,052	7.1336
	28	9	12	do		do	24,526	7.1504
	29	10	12	do		do	27,501	7.1730
	30	11	12	do		do	26,837	7.2120
July	1	12	12	do		do	24,276	7.2233
	5	13	12	do		do	22,478	7.2298
	6	14	12	do		do	22,657	7.1926
	7	15	12	do		do	23,181	7.1610
	8	16	12	do		do	26,035	7.1890
	10	17	12	do		do	22,739	7.2434
	11	18	12	do		do	27,872	7.1934
	12	19	12	do		do	31,309	7.2117
	13	20	12	do		do	29,711	7.1794
	14	21	20	do		do	22,647	7.1523
	19	22	20	do		do	25,684	7.1350
	21	23	33	do		do	25,321	7.1820
	24	24	21	do			28,103	7.1510
	25	25	31	do			26,659	7,1920
	26	26	31	do			26,301	7.2050
	27	27	40	do			28,341	7.1436
	28	28	23	do			28,552	7.1782

REMARKS.—From numbers 1 to 20, inclusive, these and the 8-inch projectiles recently fabricated were cast from the same heat; the amount of iron, therefore, shows the proportions only. After number 20 the casting of the 8-inch projectiles was discontinued. The same proportions were used as before, but the *amount* depended on other work being done in the foundry at the same time.

WEST POINT FOUNDRY,
Cold Spring, N. Y., August 2, 1882.

GENERAL: I have the honor to transmit the inspection report for 1,000 8-inch Butler projectiles, delivered at this foundry under a contract with the South Boston Foundry, dated April 7, 1882.

Accompanying it is a tabular statement of various incidental facts connected with the fabrication.

I am, general, very respectfully, your obedient servant,

C. W. WHIPPLE.
Lieutenant of Ordnance.

The CHIEF OF ORDNANCE, U. S. A.,
Washington, D. C.

INSPECTION SERVICE, UNITED STATES ORDNANCE DEPARTMENT.

CLASS 4.—PROJECTILES FOR 8-INCH M. L. RIFLED GUNS.

Inspection report of 8-inch ogiral-headed Butler projectiles for M. L. rifles, made for the United States Ordnance Department by Paulding, Kemble & Co., at the West Point Foundry under contract with South Boston Iron Company of the Chief of Ordnance dated April 7, 1882.

Subject of measurement.	Prescribed dimensions.	Allowed variations.
Projectile:	*Inches.*	
Length of cylindrical portion of body	10.2	+ 2 per cent.
Length of head	9.0	− 2 per cent.
Length of base for sabot	1.70	± .05 inch.
Total length of projectile	19.50	1 per cent.
Diameter of cylindrical portion	7.95	± .01 inch.
Diameter of base over threads	6.0	± .01 inch.
Radius of head	12.0	± .01 inch.
Thickness of bottom	2.25	± 0.1 inch.
Length of interior cavity	10.25	± 0.1 inch.
Eccentricity of axis of interior cavity		0.1 inch.
Diameter of fuze (or screw-plug) hole	1.50	± .01 inch.
Pitch of thread on fuze (or screw-plug) hole	8 to inch.	
Length of thread on fuze (or screw-plug) hole		
Diameter of hole for shell-hooks	0.5	± .01 inch.
Depth of hole for shell-hooks, cylindrical part	0.5	± .05 inch.
Distance from base of projectile	10.1	± .02 inch.
Weight of projectile		
Sabot:		
Height of sabot	1.70	± .01 inch.
Exterior diameter of sabot	7.95	
Interior diameter of sabot	5.75	
Maximum thickness of outer lip	0.45	
Minimum thickness of outer lip	0.23	
Depth of cannelure	0.80	
Maximum width	0.30	
Weight of sabot		
Weight of sabot and projectile	180 pounds.	± 2.7 pounds.

Number of 8-inch Butler projectiles examined	1,284
Number rejected for erroneous dimensions of head	1
Number rejected for erroneous dimensions of cylindric body or base	8
Number rejected for erroneous dimensions of interior cavity	33
And defects at head of cavity ("draw")	37
Number rejected for eccentricity of interior cavity	51
Number rejected for defects in material or finish	91
Number rejected for inferior tenacity	63
Total number rejected	284
Total number accepted	1,000
Weight of heaviest one (with sabot) accepted	183

Weight of lightest one (with sabot) accepted	179
Weight (with sabot) of total number accepted ... pounds	181,400
Mean weight of projectile	181.4
Number of sabots examined	1,009
Number of sabots rejected for erroneous dimensions	1
Number of sabots rejected for defects in material or finish	8
Total number of sabots rejected	9
Number of sabots accepted	1,000
Weight of total number accepted . lbs.	9,500
Mean weight of sabot ... do	9.5

Physical properties.

[See accompanying tabular statement.]

Tenacity:

Prescribed ... pounds	25,000
Allowed variations ... per cent	—3

REMARKS.—The scales used here for weighing shot are not sensitive, and the shot were stamped to the nearest half-pound. 500 shipped to Fort Munroe Arsenal; 20 (no shell hook holes) to Sandy Hook proving ground; 480 transportation requested to New York Arsenal.

I certify that I have carefully inspected the above-noted projectiles, and that they conform to the dimensions prescribed within the variations allowed; and, further, that the terms of the contract as to material and workmanship have been complied with in their manufacture.

C. W. WHIPPLE,
Lieutenant of Ordnance, Inspector.

Date of inspection, July 14, 1882.

Record of 8-inch Butler shot cast at the West Point Foundry under contract of the Chief of Ordnance with the South Boston Foundry, dated April 7, 1882.

[Accompanying inspection report dated July 14, 1882.]

Date.	Number cast.	Charge of iron in cwt.							Tenacity.	Density.	Hardness.	Condemned before completion.							Remarks.
		Gere No. 2.	Gere No. 3.	Hudson No. 1.	Hudson No. 2.	Austrian.	Scrap (wheels).	Scrap (shot).				Inferior tenacity.	Eccentricity.	Draw at head of core.	Defects in material.	Broken core.	Erroneous dimensions.	Total.	
1882.									*Pounds.*										
April 29	3	......	......	......	......	......	......	......	23,131	7.0843	......	3	......	......	......	......	......	3	Cast with base down; a "draw" was found in all extending from head of core.
May 11	30	55	......	......	5	......	......	......	19,568	7.1641	......	30	......	......	......	......	......	30	
12	30	45	10	......	5	......	......	......	22,543	7.1389	......	30	......	......	......	......	......	30	
13	5	20	20	......	......	......	......	18	28,448	7.2206	......	......	......	......	......	......	......	0	Subsequent shot cast head down, and specimens taken from base of specimen shot.
15	30	20	20	......	......	......	......	18	32,921	7.2782	......	......	......	......	......	......	......	0	
16	30	24	24	......	......	......	......	22	33,100	7.2756	......	......	......	1	......	......	......	1	
17	30	21	21	......	......	8	......	20	31,311	7.2811	......	......	......	......	1	......	......	1	
18	30	21	21	......	......	8	......	20	25,717	7.2301	......	......	......	2	1	......	......	3	The lever slipped in testing specimen; tenacity probably higher.
19	30	20	25	......	......	8	......	10	31,258	7.1581	......	......	......	3	......	......	......	3	
20	30	20	24	4	......	6	......	10	27,245	7.2110	......	......	......	2	3	......	......	5	
22	30	20	24	4	......	6	......	10	28,513	7.1365	......	......	......	......	......	......	......	0	
23	30	20	24	4	......	6	......	10	26,479	7.2037	......	......	......	......	......	......	......	0	
24	30	20	24	4	......	6	......	10	23,337 30,518	7.1586 7.1827	......	......	......	......	......	......	......	0	Specimen from base. Specimen from head.
25	30	20	25	4	......	6	......	11	26,211	7.1406	......	......	......	1	1	......	......	2	All subsequent specimens taken from head.
26	30	17	26	......	4	4	......	17	27,733	7.1393	......	......	......	......	......	......	......	0	
27	30	18	28	......	......	4	......	16	27,686	7.1954	......	......	......	3	......	......	......	3	Specimen shot not included in "number cast" each day.
29	30	18	24	......	4	4	......	20	28,627	7.2141	......	......	......	......	......	......	......	0	
30	30	18	24	......	4	4	......	20	25,671	7.2285	......	......	......	......	1	......	......	1	
31	30	19	23	......	4	4	......	20	28,358	7.2005	......	......	......	......	......	......	......	0	Metal melted in air furnace and carried to molds in ladle holding amount sufficient for five to six shot.
June 1	30	20	28	......	4	4	......	20	24,243	7.1629	......	......	......	4	......	......	......	4	
2	30	21	21	......	4	4	......	20	24,036	7.1548	......	......	......	2	1	......	......	3	
3	30	22	28	......	4	4	......	20	26,883	7.1980	......	......	......	......	......	1	......	1	
5	30	18	28	......	......	4	6	20	26,837	7.2208	......	......	......	......	......	12	......	12	
6	30	18	24	......	......	4	6	20	28,001	7.2294	......	......	......	......	1	1	2	4	Molds, in all cases, dried.

7	30	19	23	......	......	4	6	20	31,794	7.2747	....	......	......	......	1	5	......	6	
8	30	20	20	......	......	4	6	20	26,974	7.1954	....	......	......	1	1	3	1	6	
9	30	19	23	......	......	4	6	20	31,311	7.2291	....	......	......	......	......	......	......	0	"Austrian iron" used, an imported charcoal pig, certainly as hard as No. 3.
10	30	20	20	......	......	4	6	20	27,732	7.2178	....	......	......	......	......	2	......	2	
12	30	21	19	......	......	4	6	20	26,569	7.2063	....	......	......	2	......	......	1	3	
13	30	22	18	......	......	4	6	20	28,137	7.1790	....	......	......	1	1	......	......	2	
14	30	21	19	......	......	4	6	20	26,928	7.2223	....	......	......	2	1	3	......	6	At first, and for a short time, Cumberland (soft) coal was used; subsequently Riddlesburg (soft) coal; charge, 45 cwt.
15	30	22	18	......	......	4	6	20	25,828	7.2300	....	......	......	......	......	3	......	3	
16	30	22	18	......	......	4	6	20	29,392	7.2597	....	......	......	......	3	......	1	4	
17	30	22	18	......	......	4	6	20	29,621	7.2356	....	......	......	......	3	......	......	3	
19	30	22	18	......	......	4	6	20	26,883	7.2001	13.02	......	......	......	......	......	1	1	Length of cut for hardness, .635.
20	30	22	18	......	......	4	6	20	25,943	7.2150	11.86	......	......	3	......	1	......	4	Length of cut for hardness, .655.
21	30	22	18	......	......	4	6	20	25,943	7.1833	14.33	......	1	5	......	......	......	6	Length of cut for hardness, .615.
22	30	22	18	......	......	4	6	20	27,015	7.1887	12.42	......	......	4	......	......	......	4	Length of cut for hardness, .645.
23	30	22	18	......	......	4	6	20	27,966	7.2393	16.23	......	......	......	......	......	1	1	Length of cut for hardness, .590.
24	30	22	18	......	......	4	6	20	26,928	7.2141	12.72	......	......	......	1	2	1	4	Length of cut for hardness, .640.
26	30	22	18	......	......	4	6	20	30,047	7.2377	14.69	......	......	......	2	......	......	2	Length of cut for hardness, .610.
27	30	22	18	......	......	4	6	20	28,537	7.2102	14.33	......	......	......	......	......	......	0	Length of cut for hardness, .615.
28	30	22	18	......	......	4	6	20	25,133	7.2056	11.86	......	......	......	2	......	......	2	Length of cut for hardness, .655.
29	30	22	18	......	......	4	6	20	24,422	7.1832	11.59	......	......	......	3	......	......	3	Length of cut for hardness, .665.
July 13	16	22	18	......	......	4	6	20	25,091	7.2092	....	......	......	......	2	......	......	2	Thirty-four cast in this lot; the balance will be used in next contract.
Total condemned before completion, by inspector												63	1	36	29	33	8	170	
Thrown out by foreman of finishing shop for various defects during completion												......	......	......	53	......	......	53	Undoubtedly for defects of material.
Condemned after completion, by inspector												......	50	1	9	......	1	61	
Total condemned												63	51	37	91	33	9	284	
Total number of shot cast											1,284	......	......	......	......	......	......	......	
Total number of shot accepted											1,000	......	......	......	......	......	......	......	
Percentage of losses												$4\frac{9}{10}$	$3\frac{9}{10}$	$2\frac{9}{10}$	$7\frac{1}{10}$	$2\frac{6}{10}$	$\frac{7}{10}$	22	

SOUTH BOSTON FOUNDRY,
Boston, Mass., August 7, 1882.

SIR: In connection with the inspection report on the 8-inch Butler cored shot fabricated at this foundry, under contract of April 7, 1882, it may be pertinent to submit a brief statement of such matters that cannot well be embodied in the aforesaid report.

From the outset the company met with great difficulties, which they attribute in great part to the nature of the iron that had to be used on account of the tenacity required. Though this may be true to some extent, the cause, I think, should be sought elsewhere. It will be seen by the accompanying table that very little change was made in the kind and proportions of iron adopted. By a trial of others the company could readily have determined which was the best, and whether or not the trouble lay with the iron, as they supposed.

Until June 8, the projectiles were cast point down, the total being about 1,100, of which nearly 500 were finished, the others being obviously defective. Of those that I inspected, about 175 passed, but some of them were subsequently rejected for excessive weight. The principal causes for rejections were defective material, particularly in the base; shortness, and too great length of cylinder. The company tried to remedy the first by increasing the length of the risers, but this was not carried far enough. A good plan, I think, would have been to increase the length of the base for sabot, and afterwards cutting it off so as to bring the projectile within the proper length; and, as blow-holes usually occur under the riser, if one had been used instead of two, the loss on this account would have been less.

The cause of the cylinder being too long, I think, was with the molders' insufficient ramming. The diameter of the cylinder of the unfinished shot is greater than that of the base of the head, so that a ring of metal bears directly on the sand, which, if not tightly rammed, will undergo compression, allowing the metal to flow towards the head. If this is the case, the larger risers tried would probably increase this defect, so that, if it saved shot from being thrown out for defective material, it caused their rejection at another place.

The shrinkage made the point present a blunt appearance and caused a great number to be condemned for shortness. This can be overcome by making the pattern so that the projectile on coming from the flask will have on the end of the point a small cylinder, say 1½ inches in diameter and two inches long, which, after turning, will leave the head within the prescribed limits. This is the method pursued at the West Point Foundry.

After this date, in the hope of effecting an improvement, the projectiles were cast point up, with one riser in the prolongation of the axis. The pattern was made long enough so that by removing metal from the base and turning down the riser, the shot was brought within the proper limits as to length. It may be noticed that if the flask be reversed and the one riser shifted to the base, and diminishing of course the size of the opening where it was, that the result will be identical with what I have recommended for casting point down.

While fewer rejections occurred for defective material, some of the projectiles were not wholly satisfactory, as the mass in the head was not always symmetrically disposed about the axis. This may be due to faults in one of the patterns, to the molders, or to the fact that the turning is done in two different lathes, with a liability to imperfect centering.

In this method the test-specimens were taken from the head, parallel to and a short distance from the axis. In some of the cavities I noticed seams in the axis of the shot, and as the wire, by which the length of the interior cavity of the projectiles is determined, was of rather large cross-section, I procured one with a long tapering point, which I frequently inserted an inch or two beyond the end of the core, and sometimes as much as four; the number rejected for this defect being 35 as against 11 when the casting was point down.

The rapid cooling and method of casting seems to cause a tendency to open in the prolongation of the core the exterior layers "set" first, and at the same time there may be a force exerted from the direction of the walls. When the casting is with the head down, of course the greater volume above it will cause the head to be sounder. No attempt is made to "churn" the metal after pouring, nor is the shrinkage in the riser fed by any hot metal. There is also room for improvement in the way the iron is transferred from the furnace to the flasks, which I think are too far apart. Too much time is consumed, and the metal is frequently poured in a rather stiff condition. The large ladle used should run on a truck placed on rails, or else a few small ones that two men can easily handle should be employed. Dry sand would give better results, I think. The rate of cooling would be diminished and there would be no scale to be knocked off.

Just before the plan of casting was changed, I asked and obtained permission to have the limit of weight increased to 185 pounds, as it seemed as if the larger proportion would be in excess of that allowed, but afterwards noticing that those of correct dimensions weighed the proper amount I did not accept any that weighed more than the amount allowed. Some of these were afterwards turned down to the required size, when the scales showed little or no variation from 180 pounds, and they were consequently accepted. The number of these is 83. While the conclusion I have expressed may be wrong, as my experience has been very limited, I think I am safe in saying that if greater care had been taken in the various steps of manufacture but few projectiles would have been rejected, and those accepted would have been more satisfactory, and that the limits allowed, including that for weight, are ample, even for iron of this high tenacity.

The company are anxious that the projectiles manufactured by them should be excelled by no other foundry, and claim that they worked under disadvantages now removed.

Very respectfully, your obedient servant,

HENRY D. BORUP,
Lieutenant of Ordnance.

CHIEF OF ORDNANCE, U. S. A.,
Washington, D. C.

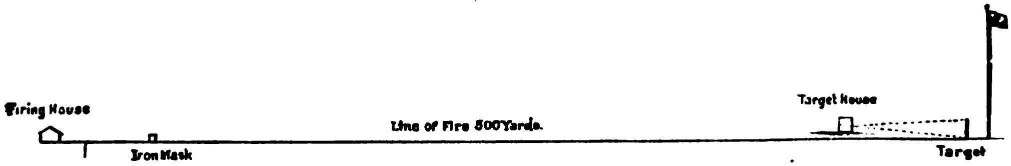
APPENDIX 21.

PRESENT METHOD OF TARGET PRACTICE AT THE FRANKFORD ARSENAL.

BY LIEUT. MARCUS W. LYON, ORDNANCE DEPARTMENT.

To test the accuracy of the daily manufacture of this arsenal, two targets of 10 shots each are fired at the 500-yard range.

The rifle or carbine (depending upon the ammunition to be tested) is securely held in the fixed rest, and after two preliminary shots have been fired to determine the point to be aimed at and to seat the piece, no further adjustment of the arm takes place for that one target, no allowance being made for any drift.



The point aimed at is so selected that the target will catch all of the shots fired. After one target has been obtained, the piece is removed, cooled by pouring water down the barrel, cleaned, dried, and oiled. The same process being repeated for each successive series of shots.

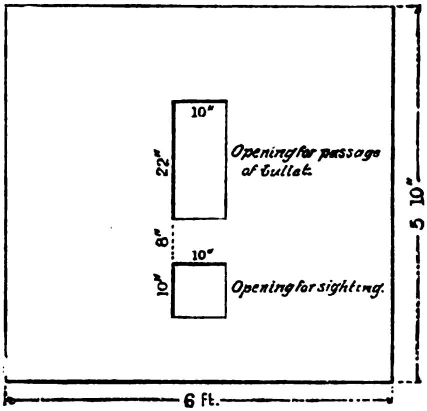
At a distance of 28 yards in front of the muzzle of the piece is placed an iron mask 6 feet wide and 5 feet 10 inches high. This has two openings; the lower one, 10 by 10 inches, is used when sighting, and, on account of the natural drift of the piece to the right, is so placed that its right-hand edge conceals about 25 inches of the right-hand side of the target, while the left-hand of the opening reveals about as much clear space to the left of the target. The upper opening, 8 inches higher on the same vertical line, is 22 inches high by 10 inches wide. Any ball that passes through this opening should hit the target.

The person firing is provided with a common telescope to enable him to watch the operations at the target. The target or camera house is placed 50 feet in front of the target and 2 feet to the left of the line of fire, being protected by an iron screen from any stray shots. This house is occupied by one of the attendants, who, by means of a camera, records upon the target diagrams, prepared for that purpose, the position and number of each shot; he also keeps the person firing informed by telephone of the results of the firing, and displays danger signals whenever necessary. In addition to this duty, at the end of each series of shots he obliterates the shot-marks by means of paint.

When many targets are to be fired, which frequently happens when testing powder or metals for cases, an additional attendant is employed, his position being behind the target where he has an unobstructed view of the river, and can lower a black curtain 8 feet high by 15 inches wide in front of the target whenever any vessel is passing.

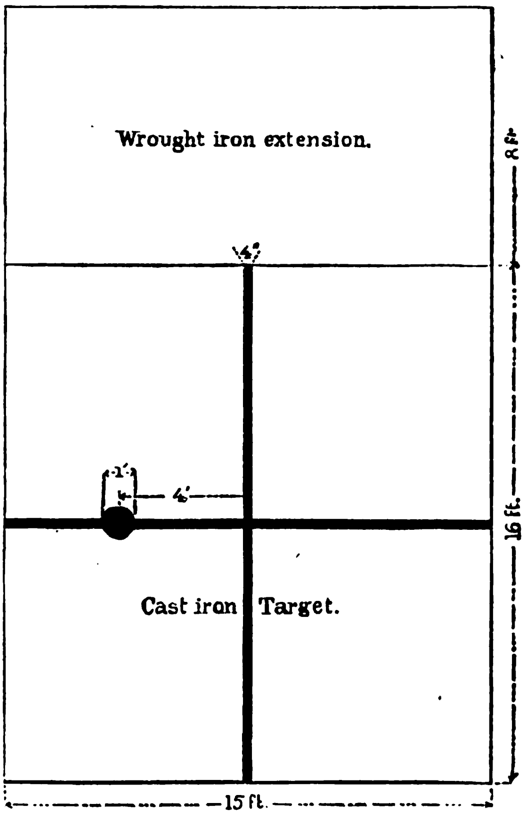
The target is made of cast iron, 15 feet wide by 16 feet high, being composed of 3 feet squares 1 inch thick, flanged and bolted together, the whole being painted white, and divided into four equal portions by a vertical and horizontal black line 4 inches wide passing through the center. Four feet to the left of the center is placed the black bull's eye, 1 foot in diameter. In order to catch any stray shots the iron mask may not stop, there is placed an extension on the top of the target 8 feet high, composed of ⅝ inch wrought-iron. Immediately in the rear of the target is a flag pole, from which a red flag is displayed during the progress of the firing.

Iron Mask, 28 Yds. in front of piece.



The original method of recording the shots on the target (devised by Capt. William Prince)[*] was by means of a camera lens and a mirror throwing an image of the target, reduced to one-twelfth, on the surface of a table. This was found to give a somewhat distorted image of the target, and on dark days much trouble was experienced on account of the lack of light; he therefore recommended the use of an achromatic lens. This, under the directions of Captains Metcalfe and Heath, was placed in successful operation, and the same image was thrown (with but little distortion) on a vertical background in an inverted position. The targets obtained by this process were, however, incorrect, as they had to be translated by reading right for left, top for bottom, and *vice versa*. Major S. C. Lyford corrected this by inverting and reversing the paper diagram; then, by pricking the shot-marks through when the paper was taken down and placed in its true position, it showed a true image of the target reduced to one-twelfth its size.

500 Yards Target.



These diagrams are afterwards plotted and made to show the following results:

The original position of each shot, by marking with lead-pencil the punctured holes made in target-house.

The point aimed at.

The center of shots; which point is determined by dividing the sum of the co-ordinates by the number of shots.

The distance from center of shots to the point aimed at.

The radius of the circle of shots, obtained by dividing the sum of the radii from center of shots by the number of shots.

This circle, together with the line joining the center of shots with the point aimed at, is always drawn on the diagrams so as to readily catch the eye, and their dimensions are placed in figures in the column prepared for that purpose.

The origin of co-ordinates is taken at the lower left-hand corner, but in working up the results it is found to facilitate the operation by taking temporarily as an origin any convenient point on the diagram. These measurements are made with the opisometer, an instrument fully described by Captain Metcalfe in *Ordnance Notes*, No. 85.

These diagrams are all numbered and signed by the person firing and the officer in charge. When five hundred of them have been made, they are bound and filed away. In addition to this, there is placed in the record-book on file in the proof-house all the facts recorded on the diagrams, with the additional record of the state of the wet and dry thermometer and the barometer, the velocity of the shots, and relative humidity of the atmosphere.

One of Lieut. D. J. Gibbons' self-registering anemometers and anemoscopes are used at the proof-house, and with this we obtain and file away the sheets showing the force and direction of the wind. In the experimental book is kept the record of all tests outside of the usual daily work. The time occupied in making a target is about 6 minutess to correctly plot the same and record the results takes about 10 minute; additional.

Small-arm cartridge experiments.

FRANKFORD ARSENAL, *September* 12, 1881.

Report number 140.
Day number 2.

Subject of experiment: Rifle cartridges S. O., No. 456.
Object of experiment: Accuracy.
The arm: Springfield rifle.
The ammunition: Rifle, service, A.

THE CIRCUMSTANCES.

. . . .

Dimensions of target, 15 by 16 feet.
Distance of target, 500 yards.
Support used, fixed rest.
Angle of sight used . . . .
Shot since last cleaned, 0.
Preliminary shots, 2.
Recorded shots, 10.
Extraction . . . .
Misses or failures, 0.

Fouling .... { Weight of barrel after target, . . . grains.
Weight of barrel before target, . . . difference.
Weight of barrel, clean, . . . difference.

Velocimeter used, . . . initial velocity.
Pressure-gauge used, . . . pressure.

Wind .. { Direction at beginning, . . . ; at end, . . . ; average, . . . ; 5 o'clock.
{ Force at beginning, . . . ; at end, . . . ; average 7 miles per hour.

Thermometer, Fah { Dry at beginning, . . . ; at end, . . . ; average 79.
{ Wet at beginning, . . . ; at end, . . . ; average 66.

Atmospheric moisture, . . . ; percentage of saturation, 54.
Barometer at beginning, . . . ; at end, . . . ; average, 30''.04.

APPENDIX 22.

THE MANUFACTURE OF RUSSET LEATHER AND ITS ADAPTABILITY FOR THE MILITARY SERVICE.

BY CAPT. D. A. LYLE, ORDNANCE DEPARTMENT.

The question having arisen as to the desirability of using russet leather for artillery harness, the writer was directed to examine into and make a report upon the subject. For this purpose he selected two typical fair-leather tanneries—one using hemlock, and the other oak bark, whose products were of acknowledged excellence.

For hemlock tannage, the tannery of The Cappon & Bertsch Leather Company of Grand Rapids, Mich., was selected. The tannery of Mr. Charles G. Smith, of Urbana, Ohio, was chosen to represent the oak tannage. Both tanneries make specialties of fair or "russet" leather.

For convenience of comparison the operations, &c., relating to the two tannages are described in parallel columns, headed, respectively, "Hemlock" and "Oak."

Explanations applicable to both tannages are made continuous across the page without regard to the columns.

"RUSSET" HARNESS LEATHER.

HEMLOCK.	OAK.
Hides.—The hides used for "russet" leather are green and salted Michigan skins. Green hides make a smoother, more uniform leather. They are carefully selected and classified. The packs are made as uniform in thickness and weight as possible. The heaviest hides are put into sole leather.	*Hides.*—Green, same as for hemlock russet. Great care taken in selection to secure uniformity in size, quality, thickness, weight, and freedom from scratches, cuts, brands, holes, &c. In the Eastern States green, salted, and South American dry hides are used by both hemlock and oak tanners.

Soaking.—The usual practice is to throw the classified packs into the "soaks" or vats, filled with soft water, for a day or two, or long enough to remove all the blood, salt, and other impurities; and then to throw them into the lime vats, paying no attention to working on the flesh until the hides come out of the lime and are put upon the beam.

This method, though sanctioned by long usage, should be discouraged, and the hides should be "fleshed" before going into the lime vats. On coming from the "soaks" the hides should be put on the beam, and the meat left on the hide in skinning "worked off," not "cut off." The latter process demands skilled labor to avoid injuring the skin and increases the cost of working—a result not consistent with true economy. But unskilled labor may be advantageously employed in a thorough *working off* of the attached meat, and still (1) break the *nerve* of the hide and (2) remove all obstructions to the uniform lining of the hides.

Where meat or grease are left upon the flesh the action of the lime is prevented, and all subsequent operations fail to produce a leather of uniform quality throughout.

A good many harness-leather tanners now remove the meat before liming, but the practice is far from universal. So far as is known to the writer, no mechanical contrivance has been devised to perform satisfactorily the unpleasant labor of "fleshing." Tanners still have to depend upon laborious manual "working." The French and German beam-knives or fleshers introduced latterly into this country have been of great advantage. The flexibility of these knives and the ease with which they accommodate themselves to the form of the convex beams readily recommend them to the enterprising tanner.

HEMLOCK.	OAK.
Splitting.—The hides are split down the back in the beam-house before liming.	*Splitting.*—Mr. Smith does not split his hides into halves at this stage.
Trimming.—This is done in the beam-house. For harness-leather especially, the sides must be carefully trimmed, or the buyer purchases at a high price a lot of useless offal fit only for upper-leather workers.	*Trimming.*—This is carefully done in the beam-house.
Liming.—After soaking, the sides are placed in the lime vats and left for five days. The liming process loosens the hair, removes the grease, and distends the fiber of the skin.	*Liming.*—After soaking, the hides are limed *low*, *i. e.*, placed in a weak solution of lime for six days. During the liming the hides are cut along the back line and great care taken to keep the edges straight in subsequent operations.
First working.—This operation is depilatory in its action, removing the hair and dirt from the grain side.	
Fleshing or second working.—This is the removal of all meat adherent to the flesh side, as well as the excess of lime and dirt upon that side.	*Fleshing.*—This is carefully done as for hemlock tanning.
Milling or wheeling.—After fleshing, the hides are put in a rotating mill, with a flow of warm water turned on, where they remain 15 minutes. This removes or knocks out the excess of lime and prepares the hide for the tan liquor.	*Milling.*—This is done after fleshing, to knock out the lime.
Bating.—The *bate* is resorted to in order to further facilitate the separation of the lime from the skin and the ease with which the tanning principle is imbibed. Messrs. Cappon & Bertsch put their hides in a weak bate of hen manure, where they are left for three hours. Some tanners bate still longer to get rid of the lime.	*Bating.*—Charles G. Smith and his superintendent, Mr. Kidder, claim that bates of hen manure, &c., for taking out lime are very irregular in their strength and action, and disapprove of their use. They remove the lime by the use of soft-water bates. For russet leather, the sides are put in a wheel or mill running 50 revolutions per minute and furnished with a continuous supply of warm water. After two days of this treatment the hides are in good condition for handling. Mr. Jackson S. Shultz also recommends the removal of the lime by warm-water bates.

Bark.—White hemlock bark from Michigan used in tanning. The bark is coarsely pulverized in a bark mill and then thoroughly leached. Black oak or quercitron bark gives a bright lemon color to leather, and forms a good finish for hemlock treated to imitate oak. Best speed for bark mill is from 90 to 120 revolutions per minute.	*Bark.*—The bark of the rock chestnut oak is used. It is ground in a bark mill and carefully leached. The bark is obtained from Southern and Central Ohio, and from the vicinity of Chattanooga, Tenn. Sumac also used. It gives a lemon color.

TANNING.

HEMLOCK.	OAK.
Handlers.—The tan liquors first used are very weak, and then gradually increase in strength until the last layaway is reached, where the strength is greatest. The liquors vary in strength, according to the barkometer, from 7° in the first handler to 20° in the layaways. The barkometer is not much used, and but little reliance is placed upon its indications. Most tanners judge of the strength of a liquor by its color and taste. The sides are six weeks passing through the handlers. The plumping or distension of the fiber is done with the gallic acid of old but moderately clean liquors. The action of this acid is to raise the skin and loosen the fiber so that it will readily absorb the tannin. The handling is done by hand, rockers not being used.	*Handlers.*—The best russet harness and saddlery leather pass through 20 handlers in succession, and occupy three months in the process. The sides are handled *every day* with the utmost care, passing from the weakest liquors to the strongest. The sides are suspended by their edges and the manipulation is all done by hand. For russet leather the vats must be kept very clean. Filthy liquors cannot be used upon this class of leather without injuring the color.
Layer or layaways.—Cappon and Bertsch use four layaways. The method of packing is as follows: First, a little liquor is placed in the botton of the vat, then a layer of dry bark is sprinkled over the bottom upon which is spread a side, then another layer of bark and a second side, and so on, alternately, until the vat is filled. When packed the vats are filled with leached tan liquor until the sides are covered. The liquor in the last layer is the strongest used, being about 20° by the barkometer.	*Layers.*—The same method of packing is employed in this case. The strongest liquor is put in the last layer. Two layers only are used; the hides remaining 30 days in each. The vats require to be kept very clean. One hundred and fifty sides are put in a vat. Mr. Smith places his sides with the *grain down* to protect them from being injured by the settling of coloring matter from the bark. The sides are taken out by hand in order to preserve the grain from hook marks.

The sides remain in the 1st layer........................15 days. 2d layer..................20 to 25 days. 3d layer.......................40 days. 4th layer........40 to 50 days (average). The *grain* side is placed *up* in the layaways to avoid scratching when removed with the hook.	Great care is taken to avoid stains on the grain in both tannages; especially the hemlock.
Washing.—This is done in a "slush" mill plentifully supplied with soft water, and making about 13 revolutions per minute. The sides are milled from five to ten minutes.	*Washing.*—The "mill" with soft water is employed for this purpose.
Scouring.—The stock-stone, a stiff brush, and clean soft water, applied by hand, are used for scouring or scrubbing.	*Scouring.*—Is done by hand and machine, with either the stock-stone or stoning-jack, stiff brushes, and soft water used for cleansing purposes.
Drying.—The drying-loft is used for this purpose. It is generally heated by steam to a temperature of from 90° to 100° Fahr.	*Drying.*—Is done in the open air or by the assistance of steam for heating the air. It is best to dry *fair* leather without the use of steam.
Bleaching: 1. Materials.—Flowers of sulphur. Alum. Sumac.	*Bleaching:* 1. Materials.—Sugar of lead. Foreign sumac.
2. Number of bleaches.—Six. After scouring the sides are passed through the six bleaches in succession. The *first* bleach has the weakest liquor. The others increase successively in strength to the sixth, which is the strongest. 3. Time: First bleach.—From 10 to 12 hours. The sides lie in this bleach over night, which is the longest time they are continuously exposed to the action of the bleaching solution. Second bleach.—Time, 12 hours. Third bleach.—Time, 15 hours. Fourth bleach.—Time, 20 hours. Fifth bleach.—Time, 24 hours. Sixth bleach.—Time, 24 hours. In the last five bleaches the sides are handled constantly without being allowed to soak in the liquor. The handling is all done by hand. Extreme cleanliness is very essential during these operations.	2. Number of bleaches.—Two or three, according to the quality of the liquors. The sides, 300 per day, are dipped successively in the liquor, and never leave the hand of the workman while in the vat; nor are they allowed to lie in the bleaches. The sumac bath is made by using two sacks of foreign sumac to 100 or 125 sides, with just enough water to cover the sides. The amount of sugar of lead employed was not given. Tanners are generally chary of giving the proportions of their baths and solutions. It has been claimed that if American sumac be gathered earlier it will be freed from its objectionable color. Mr. Kidder, of Urbana, Ohio, states that this is not true, and that it is not equal to the foreign sumac.

The exact proportions of the ingredients in the several bleaches were not given.	
Stuffing.—This is done entirely by hand—using cod oil and tallow. For "russet" leather use one-third as much stuffing as for black finished leather. Wetting turns the leather *red.* The less grease used in stuffing the less the chance for stain or objectionable change of color. By putting plenty of grease on the leather and then dampening it, the color will change to a dark red.	*Stuffing.*—Tallow and stearine (from hog's lard) is used for stuffing. The latter operation is performed by hand. Little or no oil or grease is used in finishing leather in hot weather. In cold weather a good deal of stuffing may be applied without affecting the color of the leather.
Color.—Bleached as above described, the leather assumes a beautiful pinkish cream color, which becomes lighter by drying. Rain or water will spot or stain it. The leather retains its color well in dry weather. The color is known as "a good, *live* color, light reddish in tinge." If much oil be worked in during the operation of stuffing and the leather afterwards wet, it will change to a dark reddish color. The oil causes the color to be brought out. [If great care be used in tanning and bleaching, and very little oil be used in stuffing, hemlock leather is said to be not more liable to *fade* than oak.]	*Color.*—Properly bleached, the grain of oak leather presents a bright russet color, generally known as "flesh color," with a whiter appearance than hemlock russet. It becomes a little lighter in color by drying. This is especially noticeable when the leather is finished and rolled up on a damp day and then kept from exposure to the air. It will lose color.
Section.—Light reddish, "live" appearance; cuts with apparent firmness, and does not appear fibrous or stringy.	*Section.*—This presents a "live" appearance, indicating firmness and solidity, with a bright, mottled, light-brown color.
Grain.—If the leather is *properly* treated in handling, tanning, and finishing, there will be no cracking or breaking of the grain.	*Grain.*—The same remarks will apply to oak leather, though it is less liable to crack than hemlock from careless tannage.
Poor leather.—Characteristics: cuts badly; the section has a dead, lusterless appearance; is woolly ("old hatty" technically); the grain breaks when folded sharply.	*Poor leather.*—Badly tanned leather is "old hatty" in section and harsh to the touch.
Relative strength (Cappon).—Hemlock has about the same strength as oak, and, with proper care in tanning, hemlock leather can be made as serviceable as oak. It cuts to better advantage and makes a plumper skin throughout (bellies, flanks, &c.).	*Relative strength* (Kidder).—The oak leather tanners claim that the tensile strength of their leather is greater than hemlock.
Solidity.—Good hemlock tannage makes a firm leather, but is not so	*Solidity.*—Hemlock leather has never been made to surpass the best

solid as good oak. For stamped figures and ornamentation, hemlock is found to be less retentive than oak. This effect is probably due to the greater relative sponginess of the hemlock tannages.

Inspecting.—Note the feeling when cutting with a sharp knife. Examine carefully the character and color of the section. Handle the sides one by one, noting the impressions left upon the mind through the sense of touch. Examine the sides for brands, hook-marks, scratches on the grain, gashes, thin places, grub-holes, and evidences of black-rot. Fold the sides sharply to see if the grain cracks or breaks. See that the sides are properly trimmed and that they are of uniform thickness within reasonable limits, and that the back-line is approximately straight.

Condemnation.—Reject for bad section, harshness to the touch, hardness and want of pliability, over or under tanning, acid, raw-hide streaks, serious injury to flesh or grain, improper trimming, emptiness, and flimsiness of shoulders and flanks.

Storage.—Messrs. Cappon & Bertsch say that leather will stand for two or three years without being affected injuriously, if placed in a cool, dry place—not too dry—but that it will dry a little from the evaporation of the moisture and volatile elements in the oil used for stuffing.

After that period leather will begin to deteriorate. Mr. Stout, of New Orleans, states (in a letter) that he has had Cappon & Bertsch's hemlock leather stored in an attic all summer (1881), with the thermometer ranging to 115° Fahr., and that there was "no frying out." The amount of extractive matter in the

oak in solidity. For fancy russet saddle leathers it has been found that oak retains the stamped figures longer, and the definition of the impression better, than any other leather. This is due to its superior solidity and body.

Inspecting.—See that the grain is not too heavy, or it will be liable to crack. Examine the section along the edges of the back-line, the bellies, and flanks; note the color and characteristics of the section and fiber, which should be good. See if the leather will tear easily, which indicates rottenness. Test the pliability by handling all over. The sides should be firm and solid, of uniform thickness and weight. Examine for indications of high liming, excess of acid, and imperfect or not uniform tannage. High liming softens the leather, but is injurious to strength and wear, while strong bates ruin it. Look out for streaks of raw-hide in the middle line of section.

Condemnation.—Throw aside for bad section, short tannage, raw-hide appearance, acid streak, and if too full of nerve or grain. Reject for too thick grain, for breaking or cracking on close folding, also for harshness and want of pliability.

The shoulders, flanks, and bellies should be plump and well tanned to cut to advantage.

Storage.—Messrs. C. G. Smith & Kidder state that good leather rolled, papered, sacked, and stored out of the wet in a cool, dry place —not too dry—will "stand five years without deteriorating." It should be kept from currents of air—especially fair leather. Heat evaporates the oil from the leather. Greasy russet leather should not be stored. Badly tanned leather is "old hatty," and acid leather begins to deteriorate from the day it is stored; it "dies out," becoming more brittle and rotten from day to day.

bark will affect the quality of the leather. The amount of extractive matter in hemlock can be diminished by rossing the bark before leaching.	
Stain.—The dampening of russet leather before stretching over saddle-trees discolors the surface somewhat, and has led to the practice of staining to restore the proper tint. Oak holds the stain better than hemlock.	*Stain.*—In oak tannage the use of black-oak bark (quercitron) in the last layer gives a beautiful lemon color or stain. This bark is used for making imitation oak or Union leather out of hemlock. Spanish saffron makes the best stain for russet saddles.
Cleaning.—Castile soap and water are used. The result discolors the leather.	*Cleaning.*—Same as for hemlock. Mr. Kidder suggests the "use of rock or kerosene oil for harness, and a white mineral oil for russet harness." He thinks it would be preferable to any other oil for dressing leather after washing, though he has not had much experience in its use. He says mineral oil "is not half as *hot* as fish oil," and that it will not rot the leather so quickly. He also says that "fish oil and tallow gum too much and make the harness disagreeable to handle." "Castor-oil goes right through the hide and is too gummy and penetrating."
Cost.—The price of "russet" harness leather trimmed is from 3 to 5 cents higher than black leather. If the inspection was what it should be, the cost would be greater than that above given. Since very little oil or grease is used in finishing, it follows that in buying "russet" leather by the pound less grease is bought than in any other class of leather.	*Cost.*—There are not so many operations required in the manufacture of russet leather, but the greater care and skill necessary make the cost about the same as black. The defects being more apparent, the loss from condemnation will be greater, and consequently the price must be higher to compensate for this loss. If russet leather should be adopted it would be policy to use only the best quality. Hence the necessity of having an inspector who thoroughly understands the processes of tanning, bleaching, and finishing, upon which its excellence depends.
Which leather, black or russet, would you recommend for harness? Answer.—Black. Why? It looks better after use and will wear better, because the tallow used in stuffing fills ("feeds the leather") all the pores of the sides, rendering them impervious to water, thus preventing decay. Russet leather hav-	*Which leather, black or russet, would you recommend for harness?* Answer.—Black. Why? To say nothing about the discoloration which would almost immediately follow use, russet leather is more permeable to moisture than black from the fact that so little oil or tallow is used in finishing. Con-

ing far less oil or tallow used in stuffing is very soft, pliable, and cleanly to handle, but will become discolored by sweating, rain, or by moist air.

"Russet leather makes handsome harness, but must be used only in dry weather to retain its color."—Bertsch.

Example.—A handsome set of harness came under the writer's notice this summer, that bears upon the point in question. It was made of hemlock russet by Sargent, of Boston, and contained a very good quality of leather, but not so good as samples inspected in the warehouse of Cappon and Bertsch, at Grand Rapids, Mich. This set of harness was bought in June (1881); used for light driving in dry weather; taken to the sea shore early in August, where it was used in the moist air of such resorts until about October 5, having been exposed to *one* light shower of rain. The beautiful color had changed to a murky red on the saddle and backstrap, while the breeching and traces were tinged, in addition, with a shade of grayish brown. Taken as a whole, the harness struck the observer as being dirty, but not disagreeably so.

It is a custom among buyers of russet-leather harnesses to use them until faded or stained and then to have them stained black like ordinary harness.

sequently it would begin to deteriorate earlier and more rapidly. The opportunities for deception in the manufacture of black harness leather are, however, much greater than in russet. The black staining covers minor imperfections, and the leather being filled with tallow and oil, many defects are concealed which would be plainly apparent in russet leather. Consequently the buyer stands less chance of being deceived in russet leather than in black, provided the bleaching be honest.

There is so much grease in black leather and it is so easy to cover its defects that manufacturers generally prefer to make it instead of russet leather. The former can be made to deceive the best inspectors.

Remarks.—Mr. Smith, of Urbana, Ohio, makes fair leather for fine saddles, bridles, lines, and occasionally for harness, though he prefers not to make the latter since his reputation has become established. He does not manipulate his leather to produce the maximum of weight, but to secure the best quality of leather. His prices are high, but he deals only with large firms of manufacturers, who take his whole product, and who know what constitutes excellent leather, and find it economical to buy his leather though at a higher price.

The writer being somewhat familiar with the operations of tanning and currying, carefully inspected the tannery of The Cappon and Bertsch Leather Company, at Holland, Mich., 25 miles from Grand Rapids, under the guidance of Captain Cappon. He also inspected that of Mr. Charles G. Smith, at Urbana, Ohio, in company with Mr. Kidder, his skillful superintendent.

Both these establishments are models of cleanliness and plainly indicate the care that must be taken in the manufacture of russet leather. What most impressed the observer was the manifest honesty of manipulation, both in the tannage and in the finishing operations. Much of Mr. Cappon's hemlock leather is doubtless sold as oak leather after it leaves his hands. He has the reputation of making the best hemlock russet leather in the United States.

As has been seen above, neither of these firms would recommend the use of russet leather for harness which is to be exposed in service.

To obtain still further light upon this subject the writer visited and consulted Mr. F. K. Condict, of F. K. Condict & Co., of Newark, N. J., large manufacturers of saddlery and harness; Mr. George Allen, of Newark, N. J., currier and finisher of fine russet leathers; Mr. Jackson S. Shultz, Mr. Geo. H. Stout, of New York, and other dealers in leather.

Not one of these gentlemen would recommend russet leather for serviceability in the field except Mr. Shultz, and he only on *one* condition: "that the question of *color* be overlooked *entirely*, and the leather stuffed with tallow and cod oil the same as any other harness leather." Mr. Shultz prefers neat's-foot oil to cod oil, but claims, and with reason, that it is easier to procure cod oil unadulterated than neat's-foot, owing to the high price of the latter.

The writer is under great obligations to Captain Cappon, of Holland, and Captain Bertsch, of Grand Rapids, Mich.; to Messrs. Smith and Kidder, of Urbana, Ohio; and to the several gentlemen above mentioned for valuable information and for the many kind courtesies extended to him.

BLEACHING.

In California, "skirting" and other light-colored or russet leathers are handled in warm sumac solutions immediately after coming out of the layers. After drying the leather is treated superficially with a saturated solution of oxalic acid, to which a little sulphuric acid is added to give it the desired color. The sides are next set upon a table with a very little oil, dried slowly in a dark place, and, finally, finished by rubbing with a cloth. Skirting (used for saddles, &c.) is a heavy leather; but any desired thickness may be obtained by splitting before passing through the later operations.

From the above it will be seen that although tanned with oak bark, the color is not considered satisfactory, and bleaching is resorted to in order to procure the requisite tint.

In the Eastern and Middle States fair-leather manufacturers use baths of sugar of lead and of sulphuric acid, into which the hemlock-tanned leather is alternately dipped until the wished-for effect is produced.

But, though the leather is beautiful at first, upon exposure to the light and air for a considerable time it turns a "murky brown" color, which is objectionable. These baths are very injurious to the leather. Probably the only honest bleaching process is the sumac bath. This bath involves an extra expense of from five to seven cents per side.

The sumac liquor contains a vegetable acid which acts favorably upon the sides, removing the coloring matter, softening the grain, and rendering the exterior whiter and clearer. Hemlock leather thus bleached will retain its improved color for a considerable time.

Mineral acids should never be used for bleaching purposes.

In England and on the Continent valonia is extensively used for tanning. Leather tanned with valonia is said to be harder and less permeable to water than oak-tanned.

Sicily sumac is also extensively used, but probably more for the lighter leathers.

The scarcity of oak bark and the more or less general use of valonia may account for the use of light-colored or "russet" leathers in some foreign armies. In this country valonia is too expensive for tanner's use, as it has to be imported.

It requires a little more labor to stain harness leather *black* than to finish it light-colored; but the extra care taken to exclude the light and currents of air when drying the latter, fully counterbalance any saving due to hand labor upon the former.

COST.

There would be little difference in the cost of russet and black leather, provided valonia or foreign sumac be not used. If the imported articles were used, the cost would necessarily be greater.

TENSILE STRENGTH.

If untouched by mineral acids for bleaching purposes, the strength of the two kinds—hemlock and oak—would not differ. In this country it would be almost impossible to obtain russet leather that had not been subjected to more or less of acid treatment, which would impair its quality and strength.

DURABILITY.

Russet leather, not being protected on the grain by having the pores filled with unctuous blacking, would be more permeable to water, and everything else being equal, would not be likely to be so durable as black.

EFFECT OF STORAGE.

Most leather begins to deteriorate as soon as stored. Pure bark tannages with excellent care will probably stand storing from two to five years without marked deterioration. Mr. Shultz states that with pure tannage and perfect treatment during and after tanning, leather should remain good for 15 or 20 years. He also says that good hemlock leather will stand storage from five to ten years if it be not stuffed with oil or grease, but that if made up into harness it will begin to deteriorate within periods varying from six months to one or two years.

EASE OF CLEANING.

Russet leather is more difficult to clean than black; washing alone with either water, or water and castile soap, would impair the color, and if oiled, care would have to be taken that only the best oil be used. The oil should be clarified to avoid discoloration from this source.

RESTORING LEATHER.

Mr. Shultz claims that harness that has been stored until the leather begins to get brittle and crack may be measurably restored to pliability by first dipping it in a vessel containing a mixture of one-half tallow and one-half cod or neat's-foot oil heated to a temperature of 100° Fahr., and then in hot water (about 110° Fahr.). Let the harness remain about two minutes in each, and then hang up to dry.

The hot water drives in the oil, softening the leather, and leaving the surface free from the gumminess usually attendant upon oiling.

GENERAL APPEARANCE.

When new, russet leather equipments would be striking, but probably would not accord well with the plainness of our army uniforms. They would be rather conspicuous in the field and easily discolored, presenting an appearance the reverse of military spruceness. When repairs are made the new parts would form a striking contrast to the older ones—since there is no blacking in this case to render them uniform in color.

When new, russet leather would furnish handsome horse equipments, but the stains incident upon the sweating of the animal, rain, and the spattering of mud could not be easily effaced.

Any endeavors to clean such harness would probably result in leaving areas of a murky reddish-brown color.

HEMLOCK OR OAK.

The question of whether the Army should be supplied with oak or hemlock-tanned leather has been agitated from time to time during and since the war.

The government still clings to oak, and nearly all its specifications call for oak-tanned leather, notwithstanding the fact that the greater part of the leather used during the war was bad hemlock, rendered more worthless by attempts to make it imitate oak leather. A large portion of the leather sold to the government since the war has doubtless been hemlock.

Of late years the methods of tanning with hemlock bark have improved with astonishing rapidity, and now it is the chief material used. During the past few years hemlock leather has risen greatly in the estimation of consumers. There can be no doubt that as now made it is a valuable product.

Let the specifications call for "bark-tanned" leather—either oak or hemlock—and the result will be that base imitations of oak will cease and the government will receive a better quality of leather.

There are few Army officers who *know* anything about leather, and it is not possible for Army inspectors, no matter how great their egotism may be, to detect imitations that defy the skill of expert tanners themselves.

The writer, in a report made in 1877, urged that a mixed commission of Army officers, civil or mechanical engineers, and practical tanners be appointed by the government to make a scientific investigation into the relative merits of the several tannages and to determine definitely, if possible, for what purposes the different tannages could be advantageously used. These points should be settled in time of peace, when there is no pressing need for large supplies.

CONTRACTS.

The purchase of leather by contracts given to the lowest bidder usually results in securing a stock at a price in excess of its real value, and less than that for which good leather can be bought. A change in the specifications as above indicated would doubtless better the quality somewhat by excluding the grosser imitations.

Could the purchasing agent always be depended upon for honesty, it would be more economical for the government to buy its supplies direct from the various manufacturers whose reputation for sterling integrity was above suspicion.

The government would then pay a fair price for a good article. But experience has proved that human frailty cannot withstand temptation, and the contract system had to be devised to prevent fraud and gross favoritism as much as possible.

The great defect of the contract system is that, in a measure, it legalizes fraud by rendering gross deceptions possible.

Tanners and other manufacturers of the highest standing have informed the writer that they never thought of putting in bids for government supplies, as they could not honestly fill the contract at the prices awarded. However defective the contract system may be, it is the only safeguard and protection that the government official has for his honor. There is probably no official of integrity who would not rather allow the government to get a poor article by contract than to risk being placed under the imputation of having been bribed, should he purchase a good article at a fair price from honorable dealers.

The following compound is used for oiling the harness and artillery saddles in store at the National Armory, and appears to be very satisfactory in preventing mold, preserving pliability, and freedom from stickiness and rubbing off.

HARNESS DRESSING.

[Ingredients for two gallons of the compound.]

1 gallon of neat's-foot oil.
2 pounds of bayberry tallow.
2 pounds of beeswax.
2 pounds of beef tallow.

Put the above in a pan over a moderate fire and let them remain one hour until thoroughly dissolved; then add

Two quarts of castor oil and stir well until the mass comes to a boil so that the ingredients may become thoroughly mixed; after which add—

One ounce of lamp-black and stir well for ten minutes; then strain the liquid while hot through a cotton cloth to remove sediment of beeswax, tallow, and lamp-black, and put aside to cool.

Apply this mixture to saddles and harness with a woolen cloth and leave until the next day, when they should be wiped off with a woolen cloth to remove the superfluous lamp-black.

FOR "RUSSET" OR FAIR LEATHER.

Use the same mixture without the lamp-black.

APPENDIX 23.

DESCRIPTION OF VENT PUNCH AND VENT GIMLET FOR THE LIFE-SAVING SERVICE.

MADE BY CAPT. D. A. LYLE, ORDNANCE DEPARTMENT.

(One Plate.)

These implements are designed for the removal of ordinary obstructions from the vents of the Lyle life-saving guns now in service.

VENT PUNCH.

Material.—This instrument is made from cast-steel bars, 1″ x $\frac{3}{16}$″ in cross-section.

Fabrication.—The punch is forged in steel dies and then ground to size upon an emery wheel. It is finished upon a buffing-wheel and then tempered.

DIMENSIONS.

	Inches.
Total length	5. 45
Body:	
Length	4. 50
Diameter	0. 17
Head:	
Hexagonal length of sides	0. 4
Distance between opposite sides	0. 35
Thickness	0. 20
Diameter of central hole	0. 20

Cost, at Watervliet Arsenal, 41 cents each.

This price is based upon the fabrication of the punches in lots of 200 each.

VENT GIMLET.

Material.—This gimlet is made from steel wire 0″.18 in diameter.

Fabrication.—One end of the wire has a helical groove finished with a gimlet point. The other end or head is formed into a ring. The helical groove and screw-point are made by machinery. The gimlet is carefully tempered.

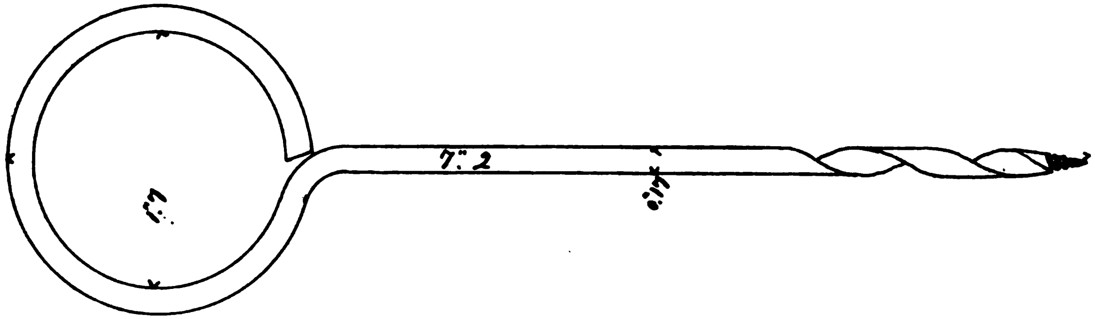
DIMENSIONS.

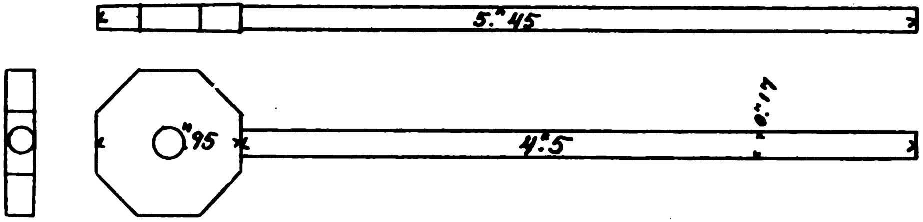
	Inches.
Total length	7. 2
Body:	
Length	5. 0
Diameter	0. 17
Helical interval groove	[illegible]
Length of screw-point	0. 25
Head—Circular ring, interior diameter	[illegible]

Cost, at Watervliet Arsenal, West Troy, N. Y., 17 cents each.

This estimate is based upon the fabrication in lots of 200 each.

Remarks.—These implements can be made at Watervliet Arsenal, West Troy, N. Y. The gimlet is made by mechanism devised at that arsenal.





LIFE-SAVING APPARATUS.

Vent Punch and Vent Gimlet.

FOR

U. S. Life-Saving Service.

1882.

APPENDIX 24.

INSTRUCTIONS FOR ASSEMBLING AND WEARING THE INFANTRY EQUIPMENTS, BLANKET-BAG PATTERN.

BY CAPT. A. L. VARNEY, ORDNANCE DEPARTMENT.

The Blanket Bag now supplied by the Ordnance Department is a substitute for the Clothing Bag of the pattern of 1874 (described in Ordnance Memorandum No. 19), and is designed to be worn without the "Carrying Brace."

Two "Blanket-bag Straps" are supplied in lieu of the brace system, each 23 inches long, 2 inches wide at one end, and $1\frac{1}{8}$ inches wide at the other. On the wide end is sewed a standing leather loop, open, on the undressed side of the strap, and having a small brass-wire loop, to receive the coat strap, on the blackened side, attached by a chape sewed and riveted under the leather loop.

A double brass-wire hook is attached to the small end of the strap, which is passed through its eye (the back of the hook toward the undressed side) and secured by another hook riveted on and passing through holes punched in the strap to regulate the length. A sliding loop slipped over the fold in the strap keeps the double-wire hook in place. The straps are attached to the bag by means of two rectangular brass-wire loops at the top. To attach the strap, remove the double-wire hook and the sliding leather loop; pass the strap through the rectangular brass loop at the top of the bag from the back of the bag toward the side of the flap, holding the blackened side of the strap toward the bag and observing that the straps are "rights" and "lefts." The straight edges of the straps should be toward the middle of the bag. Next, pass the small end of the strap through the standing leather loop at the wide end and draw the noose thus formed up close to the rectangular wire loop on the bag. The small brass loop on the strap should be drawn through the brass loop on the bag so as to remain on the outside. Next put on the sliding leather loop and then the double-wire hook.

Adjust the strap to the desired length by means of the hook at the end and pass the sliding loop over the fold in the strap.

To attach the Coat Strap, slip the sliding loop down to the buckle and pass the billet end through the small brass loop on the blanket-bag strap, holding the blackened side of the coat strap toward the bag; pull the strap through to within one foot of the buckle; pass the billet through the sliding leather loop and push the latter down close to the brass loop through which the strap passes. The coat strap should be inserted in same direction with regard to the bag as the blanket-bag straps—that is, so that when the strap hangs double over the flap of the bag the buckle end will be outside.

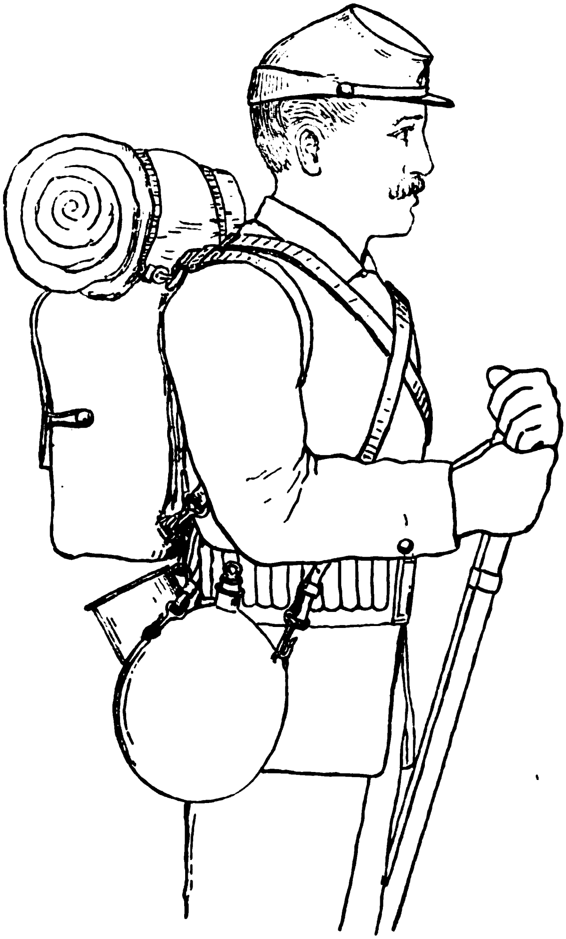
To sling the bag, first hook the left-hand strap to the D-ring on the lower left-hand corner of the bag, pass the left arm through this strap, grasp the end of the other strap with the right hand, swing the bag over the shoulders carrying the right-hand strap over the head; bring this strap down over the right shoulder and hook it into the D-ring at the lower right-hand corner of the bag. The webbing loop with button and button-hole at the bottom of the blanket bag is designed to carry the tin-cup.

When the bag is filled, the flap is fastened down by passing the leather loops at the corners over the buttons on the gussets.

A haversack strap is also made of leather and supplied with double-wire hooks at each end like those on the blanket-bag straps. These hooks are inserted into the buckles at the top of the haversack. No change has been made in the haversack except to enlarge the pocket for the meat-ration can. It can be used with either the carrying brace or the haversack strap now provided.

A leather strap similar to the haversack strap (only narrower) is now provided for the canteen. Iron-wire loops are attached to the sides of the canteen to receive the double-wire hooks on the strap.

The accompanying diagram, prepared by Capt. H. C. Cushing, 4th Artillery, shows the soldier equipped for the march.



APPENDIX 25.

CARTRIDGES AND FRICTION PRIMERS FOR THE MILITARY SERVICE.

BY LIEUT. COL. J. M. WHITTEMORE, ORDNANCE DEPARTMENT.

MILITARY CARTRIDGES FOR BREECH-LOADING SMALL-ARMS IN THE UNITED STATES SERVICE.

The requirements of a good service-cartridge are strength, durability, uniform dimensions, and cheapness. Its power should be stored up in as small a space as possible, that a soldier may carry a maximum number of rounds with a minimum effect upon his endurance. It must possess certainty of fire combined with uniform accuracy, range, and penetration. After firing, the shell must be easily extracted from its chamber. To unite all these qualities the greatest care is required in the different processes of manufacture. The materials from which the component parts of the cartridge are made, which are the shell, the primer, the powder, the bullet and lubricant, must be of the best quality. A variation of 0″.001 in the thickness of the metal disk from which the shell is drawn, from standard dimensions, produces waste of material and unnecessary wear upon the tools if above the standard, and other complications if below. The priming or explosive compound for igniting the cartridge must be made with such care and of such ingredients as will almost absolutely insure ignition from a blow of calculated strength upon the cup or cap containing it. The component parts of the powder must be sufficiently pure that when incorporated, pressed, and grained, its density may be so nearly constant that a fixed charge will give a nearly constant initial velocity to the bullet, producing a corresponding constant range and accuracy under like conditions of the atmosphere. Electric ballistic machines readily determine the initial velocity, enabling us, by slight variations of the charge, to keep that velocity practically a constant quantity, thus solving the problem of a cartridge with a measured or fixed amount of work stored up in it to be given out with deadly effect when needed. This is the state of perfection to which the cartridge is now made. In 1866, when the manufacture of the service-cartridge was commenced at Frankford Arsenal, Philadelphia, Pa., little or nothing was known as to how a good reliable military cartridge could be made. To explain the difficulties which had to be overcome at every step, the machines to be invented to do the work uniformly, accurately, and economically, would fill a large volume. It can be said, however, that through the combined efforts of the officers in command of Frankford Arsenal, Philadelphia, and the National Armory, Springfield, Mass., a cartridge was produced which would reflect credit upon any nation. Up to the present time this cartridge, perfected and slightly modified, has been the service-cartridge for breech-loading small-arms and machine guns. With the invention and adoption of breech-loading small-arms and metallic cartridge shells heavier and more uniform charges of powder were introduced, giving greater range and accuracy. This was followed by a desire and necessity for soldiers becoming trained marksmen. To meet economically the demand for an increased expenditure of ammunition thus produced, reloading shells were used. Until this demand came such shells had not been made to any extent at Frankford Arsenal, although a plan for making them had been worked up at that post which has since been quite generally adopted by all manufacturers of reloading shells in this country, and also abroad by several nations, viz, making a pocket in the head of the shell formed in the continuous metal from which it is drawn, and into which a primer could be inserted from the exterior. Reloading shells have generally been made of brass, and are now so made to a great extent. This metal possesses sufficient elasticity, but is wanting in durability, as experience has proved. The service non-reloading shell is made of copper with a small percentage of spelter, and has shown durability equal in years to those longest made. When the subject of a reloading shell received the serious attention of the Ordnance Department it was decided that similar metal should be tried for the reloader. Experiments proved that although not possessing elasticity to the extent of brass, it had enough for all practical purposes, and the important advantage of durability, as proved in the non-reloader. This metal has therefore been used by the department thus far for reloading shells. A large experience has demonstrated the fact that the service non-reloader adapted to the service-gun has no superior (if any equal) in the important qualities which a good military cartridge of that class should possess. Although reloading cartridges are required as a matter of economy for target practice, it is perhaps wise to retain the non-reloader for field service. The facts that it cannot be tampered with when once made without discovery, and retains its good qualities for action under all the tests it is subjected to in actual service, by transportation, exposure, and even immersion in water, are strong arguments for its remaining the standard cartridge for fighting purposes.

Extract from report made to the Chief of Ordnance, October* 16, 1879, *by Lieut. Col. J. M. Whittemore, commanding Frankford Arsenal, on the manufacture and test of* 100,000 *solid-head copper† reloading cartridges.*

DESCRIPTION AND TESTS.

The cartridge is of standard dimensions on the outside, approximating to the maximum.

The inside dimensions are:

1. A cylindrical bullet-seat 0''.458 diameter.
2. A frustum of cone.
3. A frustum of cone leaving the walls at junction of head 0''.05 thick.

Thickness of head through to inside, 0''.075 to 0''.080. The volume of the powder-space is a fraction less than the service-case. The weight averages 25 grains greater=3½ pounds in boxes of 1,000.

RELATIVE SENSITIVENESS AND CERTAINTY OF FIRE.

The following table shows the results obtained by dropping a one-pound weight, through the heights recorded, on the primers on their seats in the cartridge-cases:

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*An exhaustive report, made by Lieut. Charles C. Morrison, at the National Armory, under the direction of the late Col. J. G. Benton, then commanding, confirmed in the main the conclusions arrived at in the above report.

†The material used in the manufacture of these and the service-cartridge shells is sometimes called gilding metal. It is copper with a small percentage of spelter in it.

Flat anvils.

Service cup-anvil, height	1″.5 to 5″.5
Lowell primer	1″.5 to 6″.0
Frankford Arsenal experimental primer	2″.5 to 6″.0

Pointed anvils.

Berdan primer, height	1″.5 to 3″.0
Winchester primer	1″.5 to 4″.5

Taking for standard the service cup-anvil for sensitiveness and Springfield rifle for igniting power, the latter has sufficient surplus power to cover the range of all the above primers.

The Hotchkiss gun will also cover the range if provided with a spring requiring 15 pounds to start and 28 pounds to bring it to full cock. If less, it is prejudicial to the cartridge, and there may be an occasional misfire.

Only one misfire occurred in 16,000 rounds of the Frankford Arsenal primer fired from the Springfield, Hotchkiss (with spring of 15 and 28 pounds), and Gatling guns. It happened in the latter, and is supposed to have been due to bad or burned composition.

On the record of misfires the Frankford Arsenal primer is superior to all the above primers and is better adapted to magazine guns, being less sensitive to explosion when struck by the bullet of another cartridge held concentrically in a tube representing the Hotchkiss magazine and dropped from various heights, as shown by the following record:

Berdan explodes when struck by cartridge falling	5 feet.
Winchester explodes when struck by cartridge falling	20 feet.
Service cup-anvil explodes when struck by cartridge falling	35 feet.
Frankford Arsenal primer explodes when struck by cartridge falling	40 feet.

EASE OF EXTRACTION.

The average force required to extract the service-cartridge, measured by a spring-balance, in tests of daily work, is for the Springfield rifle 7 pounds, Hotchkiss rifle 14 pounds.

The experimental cartridge gives an average for 150 rounds: in the Springfield rifle 1 pound—maximum 2, minimum ½ pound; Hotchkiss rifle 8 pounds—maximum 9, minimum 6½ pounds. This includes the normal resistance of opening and cocking the latter—about 3 pounds.

Fifteen thousand rounds have been fired in both guns, with easy extraction. The Hotchkiss gun required to be lubricated at the bearing points.

STRENGTH AGAINST SHEARING.

Fired in the eprouvette, with 100 grains rifle-powder and 15 pounds weight, the experimental cartridge showed no sign of shearing. Fired in the Springfield rifle, with 80 grains English rifle-powder and 1,005 grains lead, the gun was strained but the case showed no sign of injury.

DURABILITY FOR RELOADING.

In a gun that has a yielding system at the base, like the Springfield, any solid-head cartridge will sooner or later be torn apart by repeated firing, and the result is hastened by the absence of lubrication in the chamber or on the cartridge. In a dry condition the life of the case will not exceed five rounds.

(The causes are explained in Ordnance Notes No. 114.)

A folded-head cartridge opens as the breech-block yields and relieves its walls of some of the tensile strain.

Winchester solid-head cartridges, brass (1879), taken from lots that stood reloading 150 times, can be torn apart on any line selected between the bullet-seat and the holdback at the base by firing in a dry gun, in from 3 to 7 rounds.

The experimental case has equal endurance with the Winchester brass case under like conditions. If the chamber is not excessively lubricated to reduce friction between it and the case (and, generally speaking, this obtains in firing by the lubricant of the bullet being carried into the chamber) the shell can no doubt be fired 100 times without tearing apart, or as long as the pocket endures the blows on the anvil.

Without any precaution against tearing apart, the following were fired:

150 cases in Springfield rifle	15 times.
150 cases in Hotchkiss rifle	15 times.
100 cases in Gatling gun	15 times.

In the Gatling gun the case yielded at the 13th and 14th rounds.

Lubricated cases were fired as follows without tearing apart:

100 cases in Springfield rifle	50 times each.
100 cases in Hotchkiss rifle	50 times each.

Generally, the case begins to split at the mouth at the 10th round.

WATER-PROOF QUALITY.

The following cartridges were immersed in water for 15 days:

250 Frankford Arsenal experimental	none leaked.
105 Winchester	6 leaked.
105 Lowell	5 leaked.

LEAKAGE OF GAS AROUND PRIMER.

With strict attention to tools to insure uniformity in size and smoothness of pocket and primer, an outside-primed cartridge can be made practically gas and water proof.

The Frankford Arsenal experimental case shows less leakage of gas than any other, especially on the first fire. When reloaded several times the pocket of a copper case yields more than that of a brass one, but such leakage as occurs in this way is inconsiderable, being only such as escapes previous to complete expansion of the cap, and does not injure the firing-pin.

FRICTION PRIMERS FOR CANNON.

FRANKFORD ARSENAL, *April* 11, 1879.

SIR: I have the honor to submit the following report upon the experiments made by me to remedy the defects found to exist in cannon primers.

These defects may be briefly enumerated as follows:

1. The metal from which they are made—brass—becomes rotten under certain exposures, as the damp air of magazines, salt air in proximity to salt water, etc.
2. The wax stopper to retain powder in main tube was liable to be softened and forced out when the primers were stored in warm places,

and this might also happen when the primer was inserted in the vent of a gun heated by firing. Even under favorable conditions the inertia of the wax stopper might produce a strain on the tube which would sometimes exceed its strength and burst it. Such cases have happened.

3. The formation of a loop to engage the hook of the lanyard by twisting the wire on itself was done in such a way as to punch or gnaw the wire, and thereby diminish its strength, either by improper lapping of the end of the wire on itself or by the pliers in which it was held while being twisted.

(1.) Examined under the microscope the brass of defective tubes injured by exposure or long storage is found to be disintegrated, the zinc of the alloy being reduced to an oxide and deposited as a white powder on the surface. To partially overcome this defect the brass primers have been coated with thin shellac varnish inside and outside, by dipping, which is easily done and costs but little. Such protection bids fair to produce favorable results in assisting to preserve the strength of the brass and prolong the lifetime of the primer.

But what I believe to be better is the substitution of copper for brass as the metal from which the primer should be made. It costs a little more, but it is more easily worked and more uniform in its character and strength and has superior preservative qualities.

In making 60,000 friction primers from copper little difficulty has been experienced, and the difference between the cost of the brass and copper primers is trifling.

The essential qualities of a cannon primer are strength to stand storage and certainty of fire under the practical condition of service with the gun, then simplicity and cheapness.

The copper primer possesses more lasting strength than the brass, and is therefore as cheap in the end, is just as simple in construction, and more likely to be in firing condition after long storage. If under the practical condition of firing the gun, it has all the requisite qualities to the extent that brass has, then it is a better material to make primers from.

From those actually fired here in making 60,000, and from the mechanical tests to which they have been subjected, corresponding to the strain they are likely to receive when used in the gun, I conclude that a copper primer is better than a brass one, and recommend that in future copper instead of brass be used in making friction primers for cannon, and also electric primers, for what is true for one will hold true for the other.

From the annexed table of a series of tests to which the brass and copper primers and their components have been subjected, it will be seen that brass wire is stronger than copper wire and will stand more pull for equal diameters. By increasing the diameter of the copper wire slightly this discrepancy is practically overcome.

The main tube (copper), when projecting at such different distances out of the vent as are likely to occur in practice, possesses sufficient stiffness, and in the last made was, at certain distances out of the vent, stiffer than the service brass tube, as will also be seen from the annexed table.

(2.) To overcome the faults of the wax stopper, shellac varnish in a pasty condition has been substituted for it to hold the rifle-powder in the main tube.

This will undoubtedly stand variations of temperature better than the wax and will not produce so much strain on the tube by its inertia. It will also stand the shocks of transportation, as proved by experience.

(3.) The two parts of the wires are now laid side by side, instead of across each other, before twisting to form the loop, and the pliers for holding them has smooth instead of roughened jaws, to prevent injury to the wire, either by itself or the jaws of the pliers.

TESTS OF FRICTION PRIMERS AND COMPONENTS.

Torsional and bending tests of brass and copper wire.

Torsion. (Lengths of 1″ twisted till ruptured.)			Bending. (Bends to and fro 180° till ruptured.)		
Specimen number.	Copper, turns.	Brass, turns.	Specimen number.	Copper, turns.	Brass, turns.
1	17	19	1	5	6
2	18	15	2	4	7
3	18	16	3	4	9
4	17	15	4	5	5
5	19	14	5	4	6
Averages	19.8	15.8	Averages	4.4	6.6

Pull in pounds required to ignite primers after five days' drying.

Nib of wire not bent.			Nib of wire bent 90°.			Nib of wire clinched		
Specimen number.	Copper.	Brass.	Specimen number.	Copper.	Brass.	Specimen number.	Copper.	Brass.
	Pounds.	*Pounds.*		*Pounds.*	*Pounds.*		*Pounds.*	*Pounds.*
1	30	24	1	32	34	1	24	34
2	40	33	2	39	30	2	40	20
3	33	37	3	28	20	3	42	20
4	24	28	4	34	28	4	38	26
5	38	34	5	30	30	5	38	34
Averages	35	31.2	Averages	32.6	28.4	Averages	36.4	26.8
After 24 hours' drying.			After 48 hours' drying.			Taken from the store.		
1	42	32	1	40	20	1	56	34
2	30	31	2	30	22	2	54	36
3	34	24	3	38	30	3	64	54
4	31	32	4	20	22	4	52	40
5	29	28	5	50	34	5	64	48
Averages	33.2	29.4	Averages	35.6	25.6	Averages	58	42.4

Deflection and breaking tests due to projection from vent.

Copper.			Brass.		
Projection.	Deflection.	Broke.	Projection.	Deflection.	Broke.
Inches.	*Pounds.*	*Pounds.*	*Inches.*	*Pounds.*	*Pounds.*
1.0	136	210	0.1	175	252
.2	93	193	.2	118	202
.3	80	130	.3	85	145
.4	60	120	.4	50	105
.5	50	90	.5	57	80
.6	34	72	.6	33	66
.7	22	54	.7	20	60
.8	20	42	.8	16	52
.9	16	36	.9	14	44

Pull and drop tests of wire.

Tests.	Copper.	Brass.
Pull	84 pounds.	100 pounds.
Drop, 10 pounds. 1.05 feet	....	Broke.
Drop, 10 pounds. 0.55 foot	Broke.	....
Area of wire	1''.00225	0''.00211
Diameter of wire	0 054	0''.053

APPENDIX 26.

MECHANICAL MOTION.

BY LIEUT. COL. A. R. BUFFINGTON, ORDNANCE DEPARTMENT.

(Two plates.)

NATIONAL ARMORY, *April* 20, 1882.

SIR: Herewith inclosed I have the honor to forward the description (with plates) of a machine that might be of interest to the corps if deemed of sufficient importance to justify publication as an Ordnance Note. In its present shape it is more in the nature of a mechanical curiosity than of a useful machine. It would be serviceable to an instructor as a practical illustration of the resolution of forces into components, and of the principle of mechanics that "action and reaction are equal, simultaneous, and contrary."

Respectfully, your obedient servant,

A. R. BUFFINGTON,
Lieut. Col. of Ordnance, Commanding.

PREFACE.

Plate No. 1 represents in plan and elevation a small model devised to verify and practically illustrate the theory, not as a model for a *working* machine, which would have to be constructed differently. What is called a "box" in the following description was resorted to, to bring down to a small axis a revolving face, part of, and attached to, a ring-gear. This necessitated the fixed ring-gear referred to in the description of the model, to be held in position by an arm or arbor, which supports, and around which, on a sleeve, the "box" (which incloses the whole system) revolves. The model, as shown by the plates, has no multiplying gear—"power-gear"—and no "differential" combination.

The work and power move equal distances in equal times when the pulleys described are used. There is some, a little, difference of velocity in the motion of these pulleys—there need not be—made so, for convenience of mechanical construction, but the faster running is reduced in diameter to make the rope passing over them about equal in the same time.

OBJECT TO BE ACCOMPLISHED.

For instance, to raise a weight, applying, by means of an endless rope, the power to pulley *b*, Plate 1—pulley *a* raising the weight.

The power may be removed at any point and the weight left hanging as in the use of "differential" pulley blocks.

Broadly stated, the *work* cannot move the machine, there being at every point under the action of the work a stable equilibrium depending upon the principle of action and reaction.

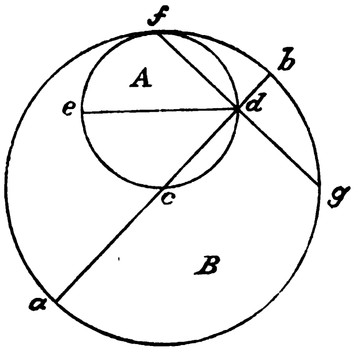
HOW THIS IS ACCOMPLISHED.

By the *mechanical* resolution of the work or resistance into two components, one of which is destroyed, in effect, by the principle of action and reaction, the other neutralized by the interposition at every point of revolution of the teeth of a fixed ring-gear.

THEORY.

Suppose, Fig. 1, the two circles *A* and *B* represent the pitch-lines of two gear-wheels, one, the larger, geared inside—a ring-gear—and twice the diameter of the other, each fixed at, but free to revolve on, its center. Any point, *d*, of the smaller will mark on the face and through the center of the other a right line, *a b*.

Fig. 1.

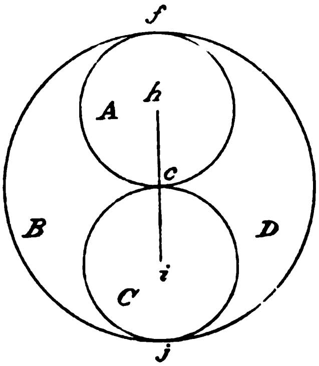


Suppose a point *over* the point *d* be fixed to a slide on the face of smaller *A* [which slide can move only in the line *d e*], and compelled to move in a groove, *a b*, across the face and center of larger *B*. If a force whose direction is the same as line *d e* be applied to this point no motion of the system can take place; for the action against the larger would be in line *f d g*, perpendicular to *a b* at *d*, and passing through *f*, the point of engagement of the two gears, and the *reaction* on smaller would be in the same line; these, action and reaction, being equal, no motion could take place. But suppose the center of smaller gear be free to move, motion would then take place—the smaller would roll around inside the other, the point referred to moving in the groove *a b*, the larger gear, although free to move around its center, remaining stationary—that is, the force applied would be resolved into two components, one perpendicular to and the other parallel with line *a b*, the former destroyed by action and reaction, the latter passing through the center of larger, producing motion only of smaller gear.

Suppose, now, two more gears precisely the same in size and gearing and having the same relation to each other be placed so that the small ones shall engage over the centers of large ones—these latter having no *direct* connection with each other—and that the centers of small ones be connected by an *arm* fixed so as to revolve at *c*, (Fig. 2); the two systems differing only in that the ring-gear (D, Fig. 2) shall be fixed—unable to move in any way.

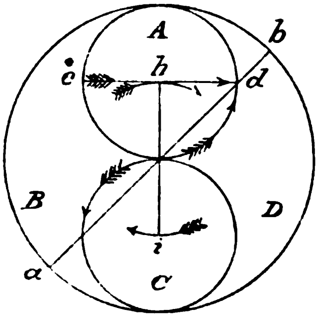
A and *B* of Fig. 2 being the two gears explained in Fig. 1, engaging at *f*; *C* and *D* (*D* and *B* coincident, showing but one circle), engaging at *j*, being the equal pair of last supposition; the smaller gears engaging at *c* and united by the arm *h i*, each free to revolve on journals of arm at *h* and *i*. If motion be given to the arm, the small gear *C* will roll around inside the fixed ring-gear *D*, and revolve the other *A* about its center *h*, as it is carried around by the arm, and *A* will carry with it the movable ring-gear *B*, or if motion be given to this latter (*B*) it will carry *A* with it, which in turn will roll *C* around inside the fixed gear *D*. During this motion any point of *A* will describe a right line across the face and center of *B* as previously noted. But if *A* and *B* be arranged with slide and groove and a force applied, as above supposed, the system cannot be moved as long as the direction of this force crosses the center of *A* in the direction of *e d* (Fig. 1). As it was shown above how the perpendicular component of the applied force is destroyed, it remains to show in what manner the parallel one is neutralized.

Fig. 2.



In Fig. 3 let *a b* represent the groove across the face and center of *B*, *d* the point of a slide on the face of *A*, and also of a block free to move in the groove *a b*, and the arrow *e d* represent the applied force and direction of it.

Fig. 3.

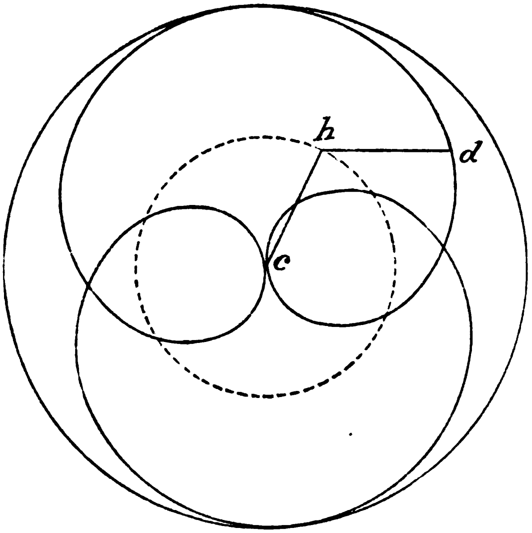


It has been seen that under the action of this force the gear *A* would start to roll around inside of *B*, as indicated by the arrow, carrying the arm *h i* as indicated, which in its turn would carry the gear *C* and give it by means of fixed gear *D* the motion indicated by the arrow. But the two small gears engage at *c*, and examining them at this point it is seen that they have motion or, strictly, tendencies to motion, in opposite directions, consequently no motion can take place, although the system is free to move either by application of force to the arm or the *free* ring-gear. Thus the teeth of a fixed ring-gear are interposed at every point of revolution to neutralize the parallel component.

To always practically have the force applied, as described, to a crank arm whose center is at *c*, a link is attached and connects with the slide, and block, as will be seen in description of model further on.

To carry over the centers, the system of four gears above explained is doubled, the crank-arms being placed at right angles on the shaft to which they are attached. The point *d* describes during a revolution a double cusp—Fig. 4—the dotted circle showing path of centers of small gears, and the broken line *c h d* one position of crank and link just referred to.

Fig. 4.



DESCRIPTION OF MODEL.

Plates I and II show the model in side and end elevations and in detail, respectively. In the side elevation are seen the gearing *c* and *d* (Plate I) connecting the pulley *b* with a system of gearing connected with the pulley *a*. The gear *d* is twice the size of *c*, as the latter's velocity must be twice the former's to give the pulley *a* a velocity equal to that of *b* when the two small gears *A* and *C*—Figs. 3 and 4, Plate II—are equal. For the convenience of mechanical construction, as stated above, these gears were made unequal, and to compensate for the difference of velocities resulting to the pulleys the pulley *b* was made a little smaller than *a*.

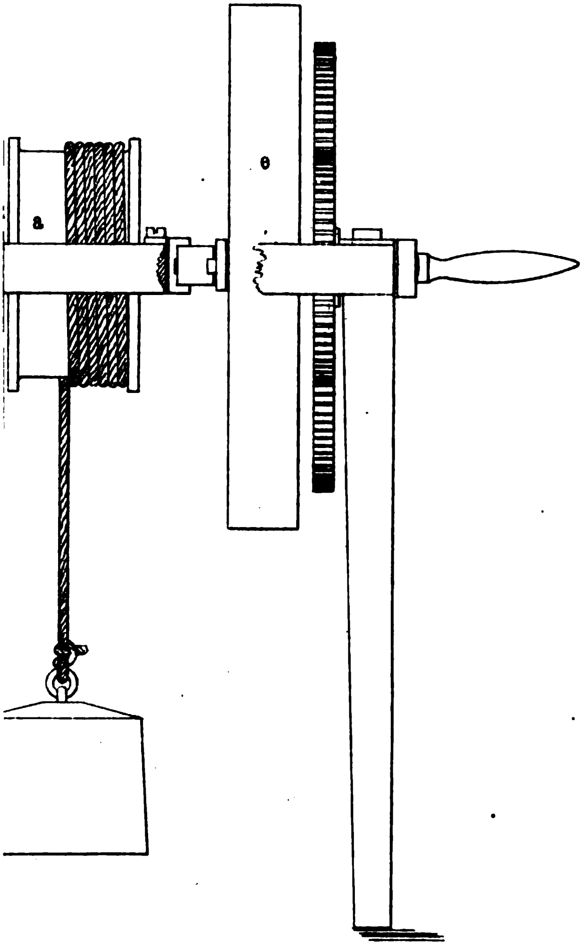
The pulley *b* is not a necessary part; it was put on the shaft to test the theory. A crank-arm, as shown in plan and elevation, or any other mechanical contrivance, may be used to communicate motion.

The caps, each held by two screws, of the hollow arms or arbors (which are fixed) do not revolve, being projections from and part of the fixed ring-gear *D*, Fig. 7 (Plate II), referred to above, shown in elevation at the center of gear *c* (Plate I), and in plan at both sides of frame), hold the arms firmly, clamp them, and consequently the ring-gear of which they are parts.

The gear *c* (Plate I), and its opposite mate are keyed firmly to sleeves that project from and form part of the box *e* (shown in detail (Plate II), Figs. 9 and 10), and its mate on opposite side; all of which is shown in section (Fig. 2, Plate II). The gear *c* turns the box *e* around the fixed hollow arm or arbor and system of gears referred to. This hollow fixed arbor forms the seat of the spindle of the arm (Plate II, Fig. 12) that carries the small gears *A* and *C* (Figs. 3 and 4, Plate II). The lid *B* (Fig. 10, Plate II) of box *e* (under-inside-face with ring-gear shown in Fig. 10, carries the movable ring-gear (which engages with the small gear *A*, Fig. 4), and has a slot across and through its center for the block, Fig. 5, to slide in. This block passes over the pin attached to the slide, Fig. 6, on the face of the small gear *A* (Fig. 4.) Fig. 8 shows the crank-arm, and Fig. 11 the link which connects it with the pin passing through the block, Fig. 5. As this link always remains over and parallel with the slide on the face of the small gear *A*, the direction of the force of the work on the pulley *a* is always through the center of said gear, thus fulfilling the condition necessary to produce the result stated. Fig. 1 (Plate II) shows a section and elevation on line *A B* of plan, Plate I, in which this can be plainly seen, as also the manner in which all the gears of the system engage.

ELEVATION.

PLATE 1.



ιNICAL MOTION,

OR MACHINE.)

o in the foregoing text.

Appendix 26—1882.

APPENDIX 27.

CONVERSION OF METRICAL INTO UNITED STATES MEASURES, AND *VICE VERSA*, WITH TABLES ADAPTED TO A COMPARISON OF OUR OWN WITH FOREIGN GUNS.

BY LIEUT. ROGERS BIRNIE, JR., ORDNANCE DEPARTMENT.

The frequently recurring necessity for changing tables expressing the dimensions, weights, and power of foreign guns (other than British) into their equivalents in our own system has suggested the preparation and compilation of these tables in the form presented.*

Some of the tables have been long since published in part, or in another form, but such have been generally based upon values for the *meter* and *kilogram*, which the latest accurate investigations have rendered obsolete; other of the tables, if ever published, are not generally accessible. All (except table M) are based upon the value of the meter in *inches* and of the kilogram in *grains*. The standard inch and grain of the United States are copies of the British: the tables therefore also express the equivalents of metrical in British measures.

MEASURES OF LENGTH, SQUARES, AND CUBIC MEASURES.

(Tables A, B, and C.)

The international bureau of weights and measures at Paris is now engaged in determining, with the utmost exactness, the relations of the French standard to those of other nations.

Since 1868 the United States Coast Survey Office has used a value for the meter equal to 39.370432 inches, as determined by an extensive series of comparisons, the results of which are published in a volume entitled "Comparisons of the Standard of Lengths of England, France, Belgium, Prussia, Russia, India, and Australia, made at the Ordnance Survey Office, Southampton, 1866." (See also a paper by Lieut. Col. A. R. Clark, in the Philosophical Transactions for 1873.)

Pending the result of the investigation at Paris, this value of the meter is generally accepted by scientific men. The fact that the meter is standard at 0° C. (32° F.) and the yard at 62° F. has been taken into account, and the value given is that of the meter in inches of the standard yard.

Tables A, B, and C, like all the remaining ones, consist of the values of each denomination, from 1 to 9 inclusive, which can be applied to all numbers, by decimal multiplication and division; as. for example:

Convert 760 millimeters into inches—Table A.

Inches.

$700^{\text{mm}} = 27.5593$

$60^{\text{mm}} = \ \ 2.36223$

$760^{\text{mm}} = 29.922$

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* Germany, Belgium, Italy, Spain, Portugal, Holland, Greece, and France have adopted the metrical system and use it generally, while in the United States its use was legalized by Congress in 1866.

WEIGHTS.—(Table D.)

The standard troy pound of the United States, at Philadelphia, is our only standard of weight: it is an exact copy of the imperial troy pound of Great Britain, obtained in 1827. Elaborate comparisons, since 1855, of this troy pound, weighing 5,760 grains, and of the commercial or avoirdupois pound of 7,000 grains, derived from the former, with copies of similar weights from the standard pound of Great Britain, have shown that there is less than $\frac{1}{1000}$ of a grain difference between the money standards (troy weights) of the two countries. (Prof. J. Hilgard in App. 22, U. S. Coast Survey Report for 1876.) The British *standard pound avoirdupois* is the weight, in the latitude of London, of a certain piece of platinum kept in the exchequer office. (Rankine's Applied Mechanics, 9th ed., page 18.)

In the Philosophical Transactions for 1856, page 893 *et seq.*, is published Prof. W. H. Miller's determination of the weight of the kilogram equal to 15,432.34874 grains, which is accepted as authoritative. This value has been used in the preparation of Table D.

AIR-SPACE PER UNIT OF WEIGHT OF POWDER-CHARGE.—(Table E.)

In the metrical system, the volume of the chamber and bore of the gun is expressed in decimeter cubes (d. c.) or liters. The space in the bore (or chamber), in rear of the projectile in place, in which the combustion of the charge takes place, constitutes the *initial volume*, and the *final volume* results when the projectile leaves the piece and the inflamed gases have expanded to completely fill the whole of the bore. The definite relation between the powder charge and the initial and final volumes, which we express by "—— cubic inches of air-space to the pound of powder," is in that system expressed by "—— decimeter cubes of air-space to the kilogram of powder." Table E enables us to convert these expressions.

PRESSURE OF AN ATMOSPHERE.—(Table F.)

The value of the *unit atmosphere* (or atmo.) which has been adopted in the metrical system, and used by Regnault in his investigations to determine the relations between the temperature and pressure of gases, is the pressure of 760 millimeters (29.922 inches) of the mercurial column at 0° C. (32° F.) at Paris; which amounts, in that latitude, to 1.0333 kilograms on the square centimeter, or 14.6967 pounds on the square inch. In consulting this table it is therefore necessary to remember that it deals with an arbitrary *unit atmosphere*.

The Encyclopædia Britannica, Vol. III, page 28, 9th ed., gives as *an atmosphere*, in the English system, the pressure due to 29.905 inches of the mercurial column at 32° F. at London, which atmosphere thus becomes 0.99968 of that of the metrical system. Under this pressure (29.905) distilled water boils at 212° F.

Rankine assumes (page 69) as the value of an English *atmosphere* the pressure due to 29.922 inches of the mercurial column at 32° F., which in the latitude of London corresponds to a pressure of 14.704 pounds per square inch. This, it will be observed, is the *height* used in the metrical system, which is thus indicated as the universal standard.

There are two ways of taking such a standard. 1st. If the *absolute pressure at Paris*, due to 76 centimeters of the mercurial column at 0° C., be assumed, then if we would have the same absolute pressure, in taking readings of the barometer for *pressures*, in a different latitude, allowance must be made for a difference of height of the mercurial column, corresponding to the difference between the latitude of the place of observation and that of Paris.

The height of the mercurial column at 0° C. giving a pressure equivalent to that of *this* metrical atmosphere, can be computed in centimeters by the following expression:

$$76 \times \frac{(1 + .00531 \sin^2 48^\circ 50')}{1 + .00531 \sin^2 l.}$$

for any latitude l.* (48° 50′ being the latitude of Paris.)

Thus we have for New York City, taking $l = 40^\circ 42' 43''$, a value for the expression, of 76.06314 centimeters=29.946 inches, which height of the mercurial column at 32° F. at New York City would indicate a pressure equivalent to the metrical atmostphere *of constant pressure.*

2d. On the other hand, assuming (as does Rankine) the universal standard to be the pressure (wherever taken) due to 29.922 inches of the mercurial column at 32° F., then the absolute pressure of *this unit atmosphere* at New York would equal but 14.686 pounds on the square inch, which is 0.999272 of the metrical atmosphere *at Paris.* It may be added that 29.922 inches of the mercurial column at 32° F. corresponds to 30 inches at 57°.8 F.; the reduction to 32° for this reading being −0.078 of an inch for an observed reading of the attached thermometer of 57°.8 F.

BENDING-STRESS PER UNIT OF LENGTH.—(Table G.)

In the case of a uniformly distributed load, or of a pressure tending to bend or burst open a structure, this table enables us to pass from "kilogrammes to the centimétre" to "pounds to the inch," &c., and *vice versa.*

STRESS PER UNIT OF SQUARE AND CUBIC MEASURES.—(Tables H and I.)

The first of these tables finds its application especially in the conversion of expressions giving the tensile strength of materials, wherein we change the metrical expression in "kilogrammes to the square millimétre" into "pounds to the square inch," otherwise stated simply as "—— pounds tensile strength." The two tables apply to the conversion of values of forces of compression; the word *stress* being used to indicate either a force of extension or compression.

UNITS OF WORK OR ENERGY.—(Table K.)

This table gives simply the equivalent values of "kilogrammètres" in "foot-pounds," and "tonnes-mètres" (sometimes written *dynamodes*) in "foot-tons." It will be used in the translation of abstract quantities of work or energy.

ENERGY OF PROJECTILES.—(Table L.)

The translation of expressions for total energies will be made by Table K, while in this series (L) we pass to expressions for energies of projectiles in terms of "units of the shot's circumference" and "units of the shot's cross-section." This series also enables us to translate the proportion of the total energy due to each kilogram of the powder-charge, each kilogram of the piece, or each kilogram of the projectile, into equivalent denominations in our own system, and *vice versa*. Further, it includes a translation of the proportion of the total energy due to each unit of the terms in which the pressure upon the bore is expressed; as, for example, "tonnes-mètres (of energy) per atmosphere of pressure" in "foot-tons per pound of pressure."

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* Enc. Brit., p. 556, Vol. XI.

In Ordnance Notes, No. XLV, Maj. George W. McKee, United States Ordnance, has already called attention to the influence of the *local* value of the force of gravity (g) in using the formula $E=\frac{Wv^2}{2g}$ (foot-note to page 290), which is employed for determining the energy of a projectile. In connection with these tables, it may be remarked that while they translate the value given in the foreign tables, yet the values thus deduced may not always be strictly comparable with each other or with our own. The practice of the United States Ordnance Department is to use a value for $g=32.2$, which is the same as that used in Great Britain; this makes the published tables of energy directly comparable for the two countries, but slightly underrates the local power of our own guns.

The French use the value of g at Paris, where it is equal to 9.81 meters=32.185 feet, which, it will be seen, gives slightly greater energies for one of their guns than we publish for one of ours, supposing all the values entering in the formula (except g) to be the same for the two guns under comparison. Small changes in the value of g will, however, make little practical difference in the published results, which, for energies, are usually given in foot-tons to tenths only.

THERMOMETERS.—(Table M.)

This table presents merely a tabulated solution of the formula

$$F^\circ=\frac{C^\circ\times 9}{5}+32=\frac{R^\circ\times 9}{4}+32.$$

By decimal multiplication and division it can be applied to all numbers. as the others. In passing from centigrade or Réaumur to Fahrenheit we first take out the tabular numbers and then add 32; in the reverse operation we first subtract 32 from the Fahrenheit degrees, to be converted into centigrade or Réaumur, and then take out the tabular numbers corresponding to this remainder, as, for example: Convert 4°.1 C. into F°; from the table we have

$$\begin{aligned}4^\circ.\ C&=7^\circ.2\ F\\ .1\text{''}&=\ .18\text{''}\\ 4^\circ.1C&=7^\circ.4F+32=39^\circ.4\ F.\end{aligned}$$

or conversely, to convert 62° F. into C.°: 62°−32°=30°, and from the table we have, 30=16.7; hence 62° F=16°.7 C.

UNITS OF HEAT.—(Table N.)

The thermal unit centigrade is the amount of heat required to raise unit mass of water from 0 to 1° C.

This table expresses the relation between the amount of heat required to raise *one kilogram* (2.2046 pounds) of water from 0 to 1° C. (1°.8 F., and the amount of heat required to raise *one pound* of water 1° F. (from 32° to 33° F). The mechanical equivalents of the "unit of heat" in the two systems bear a like relation to each other. This mechanical equivalent, in the English system, is the number of foot-pounds of mechanical energy which must be expended in order to raise the temperature of one pound of water one degree. For Farenheit's degree that quantity (Joule's equivalent) is 772 foot-pounds; for the centigrade degree $\frac{9}{5}$ of 772=1389.6 foot-pounds. If we replace the pound by a kilogram (2.2046+pounds), that quantity becomes for the centigrade degree 2.2046 of $\frac{9}{5}$ of 772=3063.54 foot-pounds, which is the mechanical equivalent of the metrical unit of heat, and is equal to 423.55 kilogrameters.

CONVERSION OF BAROMETRIC READINGS.

With barometers read by the metrical scale, to change to the corresponding reading in inches, we have only to change the number of millimeters, given by the metrical scale, into inches, for which use Table A; for example, a reading of 762 millimeters is given:

700^{mm}=27.5593 inches.
60 " = 2.3622 "
2 " = .0787 "

762^{mm}=30.0000 inches, which is the reading in inches.

CO-EFFICIENT OF ELASTICITY FOR LONGITUDINAL STRESS.

This in metrical tables is usually expressed in terms of kilograms per square millimeter. To reduce to our usual expression, which (for the weight modulus) is in terms of pounds per square inch, Table H will be used, and we have only to take from that table the number of "pounds per square inch," corresponding to the number expressing the metrical co-efficient of elasticity; as, for example, the co-efficient of elasticity (metrical) of a certain specimen of cast iron is expressed by the number 15,000. From Table H we have:

10,000 kilograms to the mm.—c=14,223,078.6 pounds to the square inch.
5,000 " " " " "= 7,111,539.3 " " " " "

15,000 =21,334,618.

which expresses the corresponding co-efficient of elasticity for this piece of metal in our own system.

A summary of all the unit values used, with their logarithms, precedes the tables herewith appended.

ROGERS BIRNIE, Jr.,
Lieutenant of Ordnance.

WEST POINT FOUNDRY,
Cold Spring, N. Y., May 15, 1882.

SUMMARY OF TABLES.

Comparison of metrical with United States measures, weights, &c.

Table.			No.	Logarithm.	Logarithm.	No.			Table.
A.	Inches in a	Millimeter	0.039370432	$\bar{2}$.5951702	1.4048298	25.399772	Millimètres	in an inch	A.
		Centimeter	0.39370432	1.5951702	0.0048298	2.5399772	Centimètres		
		Decimeter	3.9370432	0.5951702	$\bar{1}$.4048298	0.25399772	Décimetètre		
		Meter	39.370432	1.5951702	$\bar{2}$.4048298	0.025399772	Mètre		
	Feet in a	Decimeter	0.328086933	1.5159890	$\bar{0}$.4840110	3.047972	Décimètres	in a foot	
		Meter	3.28086933	0.5159890	$\bar{1}$.4840110	0.3047972	Mètre		
		Kilometer	3280.86933	3.5159890	4.4840110	0.0003047972	Kilomètre		
	Yards in a	Meter	1.09362311	0.0388677	$\bar{1}$.9611323	0.9143917	Mètre	in a yard	
		Kilometer	1093.62311	3.0388677	4.9611323	0.0009143917	Kilomètre		
	Mile in a	Meter	0.000621377	4.7933550	3.2066450	1609.33	Mètres	in a mile	
		Kilometer	0.621377	1.7933550	0.2066450	1.60933	Kilomètres		
B.	Square inches in a square	Millimeter	0.00155003	3.1903404	2.8096596	645.14836	Millimètres carrés	in a square inch	B.
		Centimeter	0.155003	1.1903404	$\bar{0}$.8096596	6.4514836	Centimètres carrés		
		Decimeter	15.5003	1.1903404	$\bar{2}$.8096596	0.064514836	Décimètres carré		
		Meter	1550.03	3,1903404	4.8096596	0.00064514836	Mètre carré		
	Square feet in a square	Decimeter	0.10764104	1.0319779	0.9680221	9.29014	Dècimétres carrés	in a square foot	
		Meter	10.764104	1.0319779	$\bar{2}$.9680221	0.0929014	Mètre carré		
	Square yards in a square meter		1.1960115	0.0777354	$\bar{1}$.9222646	0.8361123	Mètre carré in a square yard		
C.	Cubic inches in a cubic	Millimeter	0.000061025	$\bar{5}$.7855106	4.2144894	16386.61887	Millimètres cubes	in a cubic inch	C.
		Centimeter	0.061025394	2.7855106	$\bar{1}$.2144894	16.38661887	Centimètres cubes		
		Decimeter	61.02539436	1.7855106	2.2144894	0.01638661887	Décimétre cube		
		Meter	61025.39436	4.7855106	5.2144894	0.00001638062	Mètre cube		
	Cubic feet in a cubic	Decimeter	0.035315626	2.5479669	1.4520331	28.3160784	Décimétres cubes	in a cubic foot	
		Meter	35.315626	1.5479669	2.4520331	0.0283160784	Mètre cube		
	Cubic yards in a cubic meter		1.3079861	0.1160031	1.8833969	0.7645342	Mètre cube in a cubic yard		
D.	Grains in a	Gram	15.43234874	1.1884320	2.8115680	0.064798955	Gramme	in a grain	D
		Kilogram	15432.34874	4.1884320	5.8115680	0.00006479895	Kilogramme		
	Ounces (avoirdupois) in a	Gram	0.035273935	2.5474539	$\bar{1}$.4525461	28.3495454	Grammes	in an ounce (avoirdupois.)	
		Kilogram	35.273935	1.5474539	2.4525461	0.0283495454	Kilogramme		

	Pounds (avoirdupois) in a	Gramme	0.00220462132	3.3433340	$\underline{2}$.6566660	453.59263	Grammes	in a pound (avoirdupois.)	
		Kilogramme	2.20462132	0.3433340	$\underline{1}$.6566660	0.45359263	Kilogramme		
		Ton (millier)	2204.62132	3.3433340	4.6566660	0.00045359263	Tonne		
	Ton (2,240 pounds) in a	Kilogramme	0.0009842059	$\underline{4}$.9930860	3.0069140	1016.0474	Kilogrammes	in a ton (2,240 pounds.)	
		Tonne	0.98420591	1.9930860	0.0069140	1.0160474	Tonne		
E.	Cubic inches of air-space to a pound of powder in a cubic decimetre of air-space to a kilogramme of powder.		27.6806688	1.4421766	2.5578234	0.036126291	Décimètre cube of air-space to a kilogramme of powder in a cubic inch of air-space to a pound of powder.		E.
F.	Pounds to the square inch in an atmosphere.		14.6967	1.1672200	2.8327800	0.06804245	Atmosphere in a pound to the square inch		F.
	Ton to the square inch in an atmosphere		0.006561	3.8169720	2.1830280	152.4150877	Atmospheres in a ton to the square inch		
G.	Pounds to the inch in a kilogramme to the centimetre.		5.59968718	0.7481638	$\bar{1}$.2518362	0.1785814	Kilogramme to the centimètre in a pound to the inch.		G.
	Tons to the foot in a ton to the metre		0.29898255	1.4770970	0.5229030	3.33351923	Tonnes to the mètre in a ton to the foot.		
H.	Pounds to the square inch in a kilogram to the square	Millimetre	1422.3078688	3.1529936	$\underline{4}$.8470064	0.00070308274	Kilogramme to the	Millimètre carré in a pound to the square inch.	H.
		Centimetre	14.223078688	1.1529936	$\bar{2}$.8470064	0.070308274		Centimètre carré	
	Ton to the square inch in a kilogram to the square	Millimetre	0.63495884	$\underline{1}$.8027456	0.1972544	1.57490507	Kilogrammes to the	Millimètre carré in a ton to the square inch.	
		Centimetre	0.0063495884	$\bar{3}$.8027456	2.1972544	157.490507		Centimètre carré	
	Pounds to the square foot in a	Kilogram to the square metre.	0.204812311	$\bar{1}$.3113561	$\underline{0}$.6886439	4.88251819	Kilogrammes	to the mètre carré in a pound to the square foot.	
		Ton	204.812311	2.3113561	3.6886439	0.00488251819	Tonne		
	Ton to the square foot in a	Kilogram to the square metre.	0.0000914341	$\underline{5}$.9611081	4.0388919	10936.84131	Kilogrammes	to the mètre carré in a ton to the square foot.	
		Ton	0.0914341	$\bar{2}$.9611081	1.0388919	10.93684131	Tonnes		
I.	Pounds to the cubic inch in a kilogram to the cubic millimetre.		36126.29166	4.5578234	5.4421766	0.00002768067	Kilogramme to the millimètre cube in a pound to the cubic inch.		I.
	Pound to the cubic foot in a kilogram to the cubic metre.		0.06242623	2.7953671	1.2046329	16.0189	Kilogrammes to the mètre cube in a pound to the cubic foot.		
	Ton to the cubic foot in a ton to the cubic metre.		0.02786885	$\bar{2}$.4451191	1.5548809	35.882355	Tonnes to the mètre cube in a ton to the cubic foot.		
K.	Foot-pounds in a kilogram-metre		7.233075	0.8593230	$\bar{1}$.1406770	0.13825377	Kilogrammètre in a foot-pound		K.
	Foot-tons in a ton-metre		3.2290518	0.5090750	1.4909250	0.30968843	Tonnes-mètres in a foot-ton		
	Foot-pounds to an inch of circumference in a kilogram-metre to a centimetre of circumference.		18.3718474	1.2[illegible]41528	2.7358472	0.05443111	Kilogrammètre to a centimètre of circumference in a foot-pound to an inch of circumference.		

Comparison of metrical with United States measures, weights, &c.—Continued.

Table.		No.	Logarithm.	Logarithm.	No.		Table.
L.	Foot tons to an inch of circumference in a ton metre to a centimetre of circumference.	8.201717	0.913904	1.086096	0.121926	Tonne metres to a centimetre of circumference in a foot ton to an inch of circumference.	L.
	Foot tons to a square inch of cross section in a ton metre to a square centimetre of cross section.	20.832173	1.318740	2.681260	0.048003	Tonne metre to a centimetre carré of cross section in a foot ton to a square inch of cross section.	
	Foot pounds to a pound of powder (or gun) in a kilogram metre to a kilogram of powder (or gun).	3.280833	0.515984	1.484016	0.304801	Kilogrammètre to a kilogramme of powder (or gun) to a foot pound to a pound of powder (or gun).	
	Foot tons to a pound of powder (or gun) in a ton metre to a kilogram of powder (or gun).	1.464674	0.165741	1.834259	0.682746	Tonne metre to a kilogramme of powder (or gun) in a foot ton to a pound of powder (or gun).	
	Foot tons to a pound of pressure in a ton metre to an atmosphere of pressure.	0.2197190	1.3418550	0.6581450	4.5514	Tonne metres to an atmosphere of pressure in a foot ton to a pound of pressure.	
M.	Fahrenheit degrees in a Centigrade degree	1.8	0.2552725	1.7447275	0.5555556	Centigrade degree in a Fahrenheit degree	M.
	Fahrenheit degrees in a Reaumur degree	2.25	0.3521825	1.6478175	0.4444444	Reaumur degree in a Fahrenheit degree	
N.	Units of heat in a Calorie	3.9683188	0.5986060	1.4013940	0.2519960	Calorie in a unit of heat	N.

TABLE A—*Measures of length.*

Metrical into United States.						United States into metrical.						
Metres.		Inches.	Feet.	Yards.	Miles.			Millimetres.	Centimetres.	Decimetres.	Metres.	Kilometres.
Millimetres ..	0.001	0.039370432				Inches	1	25.39977	2.539977	0.2539977	0.02539977	
	2	0.078740864					2	50.79954	5.079954	0.5079954	0.05079954	
	3	0.118111296					3	76.19931	7.619931	0.7619931	0.07619931	
	4	0.157481728					4	101.59908	10.159908	1.0159908	0.10159908	
	5	0.196852160					5	126.99885	12.699885	1.2699885	0.12699885	
	6	0.236222592					6	152.39862	15.239862	1.5239862	0.15239862	
	7	0.275593024					7	177.79839	17.779839	1.7779839	0.17779839	
	8	0.314963456					8	203.19816	20.319816	2.0319816	0.20319816	
	9	0.354333888					9	228.59793	22.859793	2.2859793	0.22859793	
Centimetres .	0.01	0.39370432				Feet	1			3.047972	0.3047972	0.0003047972
	2	0.78740864					2			6.095944	0.6095944	0.0006095944
	3	1.18111296					3			9.143916	0.9143916	0.0009143916
	4	1.57481728					4			12.191888	1.2191888	0.0012191888
	5	1.96852160					5			15.239860	1.5239860	0.0015239860
	6	2.36222592					6			18.287832	1.8287832	0.0018287832
	7	2.75593024					7			21.335804	2.1335804	0.0021335804
	8	3.14963456					8			24.383776	2.4383776	0.0024383776
	9	3.54333888					9			27.431748	2.7431748	0.0027431748
Decimetres ..	0.1	3.9370432	0.3280869			Yards	1				0.9143917	0.0009143917
	2	7.8740864	0.6561739				2				1.8287834	0.0018287834
	3	11.8111296	0.9842608				3				2.7431751	0.0027431751
	4	15.7481728	1.3123477				4				3.6575668	0.0036575668
	5	19.6852160	1.6404346				5				4.5719585	0.0045719585
	6	23.6222592	1.9685216				6				5.4863502	0.0054863502
	7	27.5593024	2.2966085				7				6.4007419	0.0064007419
	8	31.4963456	2.6246954				8				7.3151336	0.0073151336
	9	35.4333888	2.9527824				9				8.2295253	0.0082295253
Metres.......	1.	39.370432	3.2808693	1.0936231	0.000621377	Miles.......	1				1609.33	1.60933
	2.	78.740864	6.5617386	2.1872462	0.001242754		2				3218.66	3.21866
	3.	118.111296	9.8426079	3.2808693	0.001864131		3				4827.99	4.82799
	4.	157.481728	13.1234772	4.3744924	0.002485508		4				6437.32	6.43732
	5.	196.852160	16.4043465	5.4681155	0.003106885		5				8046.65	8.04665
	6.	236.222592	19.6852158	6.5617386	0.003728262		6				9655.98	9.65598
	7.	275.593024	22.9660851	7.6553617	0.004349639		7				11265.31	11.26531
	8.	314.963456	26.2469544	8.7489848	0.004971016		8				12874.64	12.87464
	9.	354.333888	29.5278237	9.8426079	0.005592393		9				14483.97	14.48397
Kilometres ..	1000.		3280.8693	1093.6231	0.621377							
	2		6561.7386	2187.2462	1.242754							
	3		9842.6079	3280.8693	1.864131							
	4		13123.4772	4374.4924	2.485508							
	5		16404.3465	5468.1155	3.106885							
	6		19685.2158	6561.7386	3.728262							
	7		22966.0851	7655.3617	4.349639							
	8		26246.9544	8748.9848	4.971016							
	9		29527.8237	9842.6079	5.592393							

TABLE B.—*Surface measurements.*

Metrical into United States.					United States into metrical.					
Metres carrés.		Square inches.	Square feet.	Square yards.			Millimetres carrés.	Centimetres carrés.	Decimetres carrés.	Metres carrés.
Millimetres carrés	0. 000001	0. 00155003			Square inches	1.	645. 14836	6. 4514836	0. 064514836	0. 0006451484
	2	0. 00310006				2.	1290. 29672	12. 9029672	0. 129029672	0. 0012902967
	3	0. 00465009				3.	1935. 44507	19. 3544507	0. 193544507	0. 0019354451
	4	0. 00620012				4.	2580. 59343	25. 8059343	0. 258059343	0. 0025805934
	5	0. 00775015				5.	3225. 74179	32. 2574179	0. 322574179	0. 0032257418
	6	0. 00930018				6.	3870. 89015	38. 7089015	0. 387089015	0. 0038708901
	7	0. 01085021				7.	4516. 03851	45. 1603851	0. 451603851	0. 0045160385
	8	0. 01240024				8.	5161. 18686	51. 6118686	0. 516118686	0. 0051611869
	9	0. 01395027				9.	5806. 33522	58. 0633522	0. 580633522	0. 0058063352
Centimetres carrés	0. 0001	0. 155003			Square feet	1.			9. 29014	0. 0929014
	2	0. 310006				2.			18. 58028	0. 1858028
	3	0. 465009				3.			27. 87042	0. 2787042
	4	0. 620012				4.			37. 16056	0. 3716056
	5	0. 775015				5.			46. 45070	0. 4645070
	6	0. 930018				6.			55. 74084	0. 5574084
	7	1. 085021				7.			65. 03098	0. 6503098
	8	1. 240024				8.			74. 32112	0. 7432112
	9	1. 395027				9.			83. 61126	0. 8361126
Decimetres carrés	0. 01	15. 5003	0. 10764104		Square yards	1.				0. 8361123
	2	31. 0006	0. 21528208			2.				1. 6722246
	3	46. 5009	0. 32292312			3.				2. 5083369
	4	62. 0012	0. 43056416			4.				3. 3444492
	5	77. 5015	0. 53820520			5.				4. 1805615
	6	93. 0018	0. 64584624			6.				5. 0166738
	7	108. 5021	0. 75348728			7.				5. 8527861
	8	124. 0024	0. 86112832			8.				6. 6888984
	9	139. 5027	0. 96876936			9.				7. 5250107
Metres carrés	1.	1550. 03	10. 764104	1. 1960115						
	2.	3100. 06	21. 528208	2. 3920230						
	3.	4650. 09	32. 292312	3. 5880345						
	4.	6200. 12	43. 056416	4. 7840460						
	5.	7750. 15	53. 820520	5. 9800575						
	6.	9300. 18	64. 584624	7. 1760690						
	7.	10850. 21	75. 348728	8. 3720805						
	8.	12400. 24	86. 112832	9. 5680920						
	9.	13950. 27	96. 876936	10. 7641035						

TABLE C.—*Cubic measures (volumes).*

Metrical into United States.					United States into metrical.					
Metres cubes.		Cubic inches.	Cubic feet.	Cubic yards.			Millimetres cubes.	Centimetres cubes.	Decimetres cubes.	Metres cubes.
									Liters.	
Millimetres cubes	.000000001	0. 000061025			Cubic inches	1.	16386. 61887	16. 38661887	0. 0163866188	0. 00001638662
	2	0. 000122051				2.	32773. 23774	32. 77323774	0. 0327732377	0. 00003277324
	3	0. 000183076				3.	49159. 85661	49. 15985661	0. 0491598566	0. 00004915986
	4	0. 000244102				4.	65546. 47548	65. 54647548	0. 0655464755	0. 00006554647
	5	0. 000305127				5.	81933. 09435	81. 93309435	0. 0819330943	0. 00008193309
	6	0. 000366152				6.	98319. 71322	98. 31971322	0. 0983197132	0. 00009831971
	7	0. 000427178				7.	114706. 38209	114. 70633209	0. 1147063321	0. 00011470633
	8	0. 000488203				8.	131092. 95096	131. 09295096	0. 1310929509	0. 00013109295
	9	0. 000549228				9.	147479. 56983	147. 47956983	0. 1474795698	0. 00014747957
Centimetres cubes	0. 000001	0. 06102539			Cubic feet	1.			28. 31608	0. 02831608
	2	0. 12205079				2.			56. 63216	0. 05663216
	3	0. 18307618				3.			84. 94824	0. 08494824
	4	0. 24410158				4.			113. 26432	0. 11326432
	5	0. 30512697				5.			141. 58040	0. 14158040
	6	0. 36615237				6.			169. 89648	0. 16989648
	7	0. 42717776				7.			198. 21256	0. 19821256
	8	0. 48820315				8.			226. 52864	0. 22652864
	9	0. 54922855				9.			254. 84472	0. 25484472
Decimetres cubes (liters).	0. 001	61. 025394	0. 03531563		Cubic yards	1.				0. 764534
	2	122. 050789	0. 07063125			2.				1. 529068
	3	183. 076183	0. 10594688			3.				2. 293603
	4	244. 101577	0. 14126250			4.				3. 058137
	5	305. 126972	0. 17657813			5.				3. 822617
	6	366. 152366	0. 21189376			6.				4. 587205
	7	427. 177761	0. 24720938			7.				5. 351739
	8	488. 203155	0. 28252501			8.				6. 116274
	9	549. 228549	0. 31784063			9.				6. 880808
Metres cubes	1	61025. 39436	35. 315626	1. 3079861						
	2	122050. 78872	70. 631252	2. 6159722						
	3	183076. 18308	105. 946878	3. 9239583						
	4	244101. 57744	141. 262504	5. 2319444						
	5	305126. 97180	176. 578130	6. 5399305						
	6	366152. 36616	211. 893756	7. 8479167						
	7	427177. 76052	247. 209382	9. 1559028						
	8	488203. 15488	282. 525008	10. 4638889						
	9	549228. 54924	317. 840634	11. 7718750						

TABLE D.—*Weights.*

Metrical into United States.						United States into metrical.				
		Grains.	Ounces (avoirdupois).	Pounds (avoirdupois).	Tons (2,240 lbs).			Grams.	Kilograms.	Tons.
Grammes (.001 of a kilogram) ..	1.	15. 4323487	0. 03527393	0. 0022046213	....	Grains	1.	0. 06479895	0. 00006479895	....
	2.	30. 8646975	0. 07054787	0. 0044092426	....		2.	0. 12959790	0. 00012959790	....
	3.	46. 2970462	0. 10582180	0. 0066138640	....		3.	0. 19439685	0. 00019439685	....
	4.	61. 7293950	0. 14109574	0. 0088184853	....		4.	0. 25919580	0. 00025919580	....
	5.	77. 1617437	0. 17636967	0. 0110231066	....		5.	0. 32399475	0. 00032399475	....
	6.	92. 5940924	0. 21164361	0. 0132277279	....		6.	0. 38879370	0. 00038879370	....
	7.	108. 0264412	0. 24691754	0. 0154323492	....		7.	0. 45359265	0. 00045359265	....
	8.	123. 4587899	0. 28219148	0. 0176369706	....		8.	1. 51839160	0. 00151839160	....
	9.	138. 8911387	0. 31746541	0. 0198415919	....		9.	1. 58319055	0. 00158319055	....
Kilogrammes	1	15432. 349	35. 27393	2. 20462132	0. 0009842059	Ounces (avoirdupois)	1.	28. 3495454	0. 028349545	....
	2	30864. 697	70. 54787	4. 40924264	0. 0019684118		2.	56 6990908	0. 056699091	....
	3	46297. 046	105. 82180	6. 61386396	0. 0029526177		3.	85. 0486362	0. 085048636	....
	4	61729. 395	141. 09574	8. 81848528	0. 0039368236		4.	113. 3981816	0. 113398182	....
	5	77161. 744	176. 36967	11. 02310660	0. 0049210295		5.	141. 7477270	0. 141747727	....
	6	92594. 092	211. 64361	13. 22772792	0. 0059052355		6.	170. 0972724	0. 170097272	....
	7	108026. 441	246. 91754	15. 43234924	0. 0068894414		7.	198. 4468178	0. 198446818	....
	8	123458. 780	282. 19148	17. 63697056	0. 0078736473		8.	226. 7963632	0. 226796363	....
	9	138891. 139	317. 46541	19. 84159188	0. 0088578532		9.	255. 1459086	0. 255145909	....
Tonnes (1,000 kilogrammes)....	1	....	....	2204. 62132	0. 9842059	Pounds (avoirdupois)	1.	453. 59263	0. 45359263	0. 0004535926
	2	....	....	4409. 24264	1. 9684118		2.	907. 18526	0. 90718526	0. 0009071853
	3	....	....	6613. 86396	2. 9526177		3.	1360. 77789	1. 36077789	0. 0013607779
	4	....	....	8818. 48528	3. 9368236		4.	1814. 37052	1. 81437052	0. 0018143705
	5	....	....	11023. 10660	4. 9210295		5.	2267. 96315	2. 26796315	0. 0022679631
	6	....	....	13227. 72792	5. 9052355		6.	2721. 55578	2. 72155578	0. 0027215558
	7	....	....	15432. 34924	6. 8894414		7.	3175. 14841	3. 17514841	0. 0031751484
	8	....	....	17636. 97056	7. 8736473		8.	3628. 74104	3. 62874104	0. 0036287410
	9	....	....	19841. 59188	8. 8578532		9.	4082. 33367	4. 08233367	0. 0040823337
....		....	....	....	....	Tons (2,240 pounds) ..	1.	....	1016. 0474	1. 0160474
....		....	....	....	....		2.	....	2032. 0949	2. 0320949
....		....	....	....	....		3.	....	3048. 1423	3. 0481423
....		....	....	....	....		4.	....	4064. 1897	4. 0641897
....		....	....	....	....		5.	....	5080. 2371	5. 0802371
....		....	....	....	....		6.	....	6096. 2846	6. 0962846
....		....	....	....	....		7.	....	7112. 3320	7. 1123320
....		....	....	....	....		8.	....	8128. 3794	8. 1283794
....		....	....	....	....		9.	....	9144. 4269	9. 1444269

TABLE E.—*Air-space per unit of weight of powder-charge.*

Metrical into United States.			United States into metrical.		
		Cubic inches of air-space per pound of powder.			Décimétre cubes of air-space per kilogramme of powder.
Décimètre cubes of air-space per kilogramme of powder.	1	27.6806689	Cubic inches of air-space per pound of powder.	1	0.03612629
	2	55.3613376		2	0.07225258
	3	83.0420064		3	0.10837887
	4	110.7226752		4	0.14450516
	5	138.4033439		5	0.18063145
	6	166.0840127		6	0.21675775
	7	193.7646815		7	0.25288404
	8	221.4453503		8	0.28901033
	9	249.1260191		9	0.32513662

TABLE F.—*Pressure in atmospheres.*

Metrical into United States.			United States into metrical.		
		Pounds on square inch.			Atmospheres, (met. system).
Atmospheres (met. system).	1	14 6967	Pounds on the square inch.	1	0.06804245
	2	29.3934		2	0.13608490
	3	44.0901		3	0.20412735
	4	58.7868		4	0.27216980
	5	73.4835		5	0.34021225
	6	88.1802		6	0.40825470
	7	102.8769		7	0.47629715
	8	117.5736		8	0.54433960
	9	132.2703		9	0.61238205
		Tons on square inch.			Atmospheres, (met. system).
Atmospheres (met. system).	1	0.006561	Tons on the square inch ...	1	152.4151
	2	0.013122		2	304.8302
	3	0.019683		3	457.2453
	4	0.026244		4	609.6604
	5	0.032805		5	762.0754
	6	0.039366		6	914.4905
	7	0.045927		7	1066.9056
	8	0.052488		8	1219.3207
	9	0.059049		9	1371.7358

TABLE G.—*Bending-stress per unit of length.*

Metrical into United States.			United States into metrical.		
		Pounds to the inch.			Kilogrammes to the centimètre.
Kilogrammes to the centimètre.	1	5.599687	Pounds to the inch	1	0.1785814
	2	11.199374		2	0.3571628
	3	16.799062		3	0.5357442
	4	22.398749		4	0.7143256
	5	27.998436		5	0.8929070
	6	33.598123		6	1.0714884
	7	39.197810		7	1.2500698
	8	44.797497		8	1.4286512
	9	50.397185		9	1.6072326
		Tons to the foot.			Tonnes to the mètre.
Tonnes to the mètre........	1	0.29998	Tons to the foot............	1	3.83352
	2	0.59996		2	6.66704
	3	0.89994		3	10.00056
	4	1.19993		4	13.33408
	5	1.49991		5	16.66760
	6	1.79989		6	20.00112
	7	2.09988		7	23.33464
	8	2.39986		8	26.66816
	9	2.69984		9	30.00168

TABLE H.—*Stress per unit of square measure.*

Metrical into United States.

		Pounds to the square inch.	Tons to the square inch.	Pounds to the square foot.	Tons to the square foot.
Kilogrammes to the millimètre carré.	1	1422.30786	0.63495884		
	2	2844.61572	1.26991768		
	3	4266.92358	1.90487652		
	4	5689.23144	2.53983536		
	5	7111.53930	3.17479420		
	6	8533.84716	3.80975304		
	7	9956.15502	4.44471188		
	8	11378.46288	5.07967072		
	9	12800.77074	5.71462956		
Kilogrammes to the centimètre carré.	1	14.2230786	0.006349588		
	2	28.4461572	0.012699176		
	3	42.6692358	0.019048765		
	4	56.8923144	0.025398354		
	5	71.1153930	0.031747942		
	6	85.3384716	0.038097530		
	7	99.5615502	0.044447119		
	8	113.7846288	0.050796707		
	9	128.0077074	0.057146296		
Kilogrammes to the mètre carré.	1			0.2048123	0.0000914341
	2			0.4096246	0.0001828682
	3			0.6144369	0.0002743023
	4			0.8192492	0.0003657364
	5			1.0240615	0.0004571705
	6			1.2288738	0.0005486046
	7			1.4336861	0.0006400387
	8			1.6384984	0.0007314728
	9			1.8433107	0.0008229069
Tonnes to the mètre carré.	1			204.8123	0.0914341
	2			409.6246	0.1828682
	3			614.4369	0.2743023
	4			819.2492	0.3657364
	5			1024.0615	0.4571705
	6			1228.8738	0.5486046
	7			1433.6861	0.6400387
	8			1638.4984	0.7314728
	9			1843.3107	0.8229069

United States into metrical.

		Kilogrammes to the millimètre carré.	Kilogrammes to the centimètre carré.	Kilogrammes to the mètre carré.	Tonnes to the mètre carré.
Pounds to the square inch.	1	0.0007030827	0.07030827		
	2	0.0014061654	0.14061664		
	3	0.0021092481	0.21092481		
	4	0.0028123308	0.28123308		
	5	0.0035154135	0.35154135		
	6	0.0042184962	0.42184962		
	7	0.0049215789	0.49215789		
	8	0.0056246616	0.56246616		
	9	0.0063277443	0.63277443		
Tons to the square inch	1	1.57490507	157.490507		
	2	3.14981014	314.981014		
	3	4.72471521	472.471521		
	4	6.29962028	629.962028		
	5	7.87452535	787.452535		
	6	9.44943042	944.943042		
	7	11.02433549	1102.433549		
	8	12.59924056	1259.924056		
	9	14.17414563	1417.414563		
Pounds to the square foot.	1			4.882518	0.004882518
	2			9.765036	0.009765036
	3			14.647554	0.014647554
	4			19.530072	0.019530072
	5			24.412590	0.024412590
	6			29.295108	0.029295108
	7			34.177626	0.034177626
	8			39.060144	0.039060144
	9			43.942662	0.043942662
Tons to the square foot	1			10936.84	10.93684
	2			21873.68	21.87368
	3			32810.52	32.81052
	4			43747.36	43.74736
	5			54684.19	54.68419
	6			65621.03	65.62103
	7			76557.87	76.55787
	8			87494.71	87.49471
	9			98431.55	98.43155

Table I.—*Stress per unit of cubic measure.*

Metrical into United States.			United States into metrical.		
		Pounds to the cubic inch.			Kilogrammes to the millimètre cube.
Kilogrammes to the millimètre cube.	1.	36126.29167	Pounds to the cubic inch...	1.	0.00002768067
	2.	72252.58333		2.	0.00005536134
	3.	108378.87500		3.	0.00008304201
	4.	144505.16667		4.	0.00011072268
	5.	180631.45833		5.	0.00013840335
	6.	216757.75000		6.	0.00016608402
	7.	252884.04167		7.	0.00019376469
	8.	289010.83333		8.	0.00022144536
	9.	325136.62500		9.	0.00024912603
		Pounds to the cubic foot.			Kilogrammes to the mètre cube.
Kilogrammes to the mètre cube.	1.	0.062426	Pounds to the cubic foot...	1.	16.0189
	2.	0.124852		1.	32.0378
	3.	0.187279		3.	48.0567
	4.	0.249705		4.	64.0756
	5.	0.312131		5.	80.0945
	6.	0.374557		6.	96.1134
	7.	0.436984		7.	112.1323
	8.	0.499410		8.	128.1512
	9.	0.561836		9.	144.1701
		Tons to the cubic foot.			Tonnes to the mètre cube.
Tonnes (1,000 kilos) to the mètre cube.	1.	0.02787	Tonnes to the cubic foot...	1.	35.882
	2.	0.05574		2.	71.764
	3.	0.08361		3	107.647
	4.	0.11148		4.	143.529
	5.	0.13934		5.	179.411
	6.	0.16721		6.	215.294
	7.	0.19508		7.	251.176
	8.	0.22295		8.	287.058
	9.	0.25082		9.	322.941

Table K.—*Units of work or energy.*

Metrical into United States.			United States into metrical.		
		Foot-pounds.			Kilogrammètres.
Kilogrammètres	1	7.233075	Foot-pounds	1	0.13825377
	2	14.466150		2	0.27650755
	3	21.699225		3	0.41476133
	4	28.932300		4	0.55301511
	5	36.165375		5	0.69126888
	6	43.398450		6	0.82952266
	7	50.631525		7	0.96777644
	8	57.864600		8	1.10603022
	9	65.097675		9	1.24428399
		Foot-tons.			Tonnes mètres.
Tonnes-mètres	1	3.2290518	Foot tons	1	0.30968843
	2	6.4581036		2	0.61937686
	3	9.6871554		3	0.92906528
	4	12.9162072		4	1.23875371
	5	16.1452590		5	1.54844214
	6	19.3743108		6	1.85813057
	7	22.6033626		7	2.16781899
	8	25.8324144		8	2.47750742
	9	29.0614662		9	2.78719585

TABLE L.—*Energy of projectile.*

Metrical into United States.			United States into metrical.		
		Foot-pounds per inch of circumference.			Kilogrammètres per centimètre of circumference.
Kilogrammètres per centimètre of circumference.	1	18. 3718474	Foot-pounds per inch of circumference.	1	0. 05443111
	2	36. 7436949		2	0. 10886222
	3	55. 1155423		3	0. 16329334
	4	73. 4873898		4	0. 21772445
	5	91. 8592372		5	0. 27215556
	3	110. 2310847		6	0. 32658667
	7	128. 6029321		7	0. 38101778
	8	146. 9747796		8	0. 43544690
	9	165. 3466270		9	0. 48988001
		Foot-tons per inch of circumference.			Tonnes-mètres per centimètre of circumference
Tonnes-mètres per centimètre of circumference.	1	8. 201717	Foot-tons per inch of circumference.	1	0. 121926
	2	16. 403434		2	0. 243851
	3	24. 605151		3	0. 365777
	4	32. 806868		4	0. 487702
	5	41. 008585		5	0. 609628
	6	49. 210302		6	0. 731554
	7	57. 412019		7	0. 853479
	8	65. 613736		8	0. 975405
	9	73. 815453		9	1. 097331
		Foot-tons per square inch of cross section.			Tonnes-mètres per centimètre carré of cross-section.
Tonnes-mètres per centimètre carré of cross-section.	1	20. 832173	Foot-tons per square inch of cross-section.	1	0. 0480027
	2	41. 664346		2	0. 0960053
	3	62. 496519		3	0. 1440080
	4	83. 328692		4	0. 1920107
	5	104. 160865		5	0. 2400133
	6	124. 993038		6	0. 2880160
	7	145. 825211		7	0. 3360187
	8	166. 657384		8	0. 3840214
	9	187. 489557		9	0. 4320240
		Foot-pounds per pound of powder, piece, or projectile.			Kilogrammètres per kilogramme of powder, piece, or projectile.
Kilogrammètres per kilogramme of powder, piece, or projectile.	1	3. 2808693	Foot-pounds per pound of powder, piece, or projectile.	1	0. 3047972
	2	6. 5617386		2	0. 6095944
	3	9. 8426079		3	0. 9143916
	4	13. 1234772		4	1. 2191888
	5	16. 4043465		5	1. 5239860
	6	19. 6852158		6	1. 8287783
	7	22. 9660851		7	2. 1335805
	8	26. 2469544		8	2. 4383777
	9	29. 5278237		9	2. 7431749
		Foot-tons per pound of powder, piece, or projectile.			Tonnes-mètres per kilogramme of powder, piece, or projectile.
Tonnes-mètres per kilogramme of powder, piece, or projectile.	1	1. 46467	Foot-tons per pound of powder, piece, or projectile.	1	0. 68275
	2	2. 92935		2	1. 36549
	3	4. 39402		3	2. 04824
	4	5. 85869		4	2. 73098
	5	7. 32337		5	3. 41373
	6	8. 78804		6	4. 09647
	7	10. 25272		7	4. 77922
	8	11. 71739		8	5. 46197
	9	13. 18207		9	6. 14471

TABLE L.—*Energy of projectile*—Continued.

		Foot-tons per pound of pressure.			Tonnes-mètres per atmosphere of pressure.
Tonnes-mètres per atmosphere of pressure.	1	0. 219712	Foot-tons per pound of pressure.	1	4. 5514
	2	0. 439424		2	9. 1028
	3	0. 659136		3	13. 6542
	4	0. 878848		4	18. 2056
	5	1. 098560		5	22. 7570
	6	1. 318272		6	27. 3084
	7	1. 537984		7	31. 8598
	8	1. 757696		8	36. 4112
	9	1. 977408		9	40. 9626

TABLE M.—*Thermometers.*

Centigrade degrees into Fahrenheit.				Fahrenheit degrees into centigrade.		
		Fahrenheit degrees.				Centigrade degrees.
Centigrade degrees	1	1. 8	+32	Fahrenheit degrees—32	1	0. 55555
	2	3. 6			2	1. 11111
	3	5. 4			3	1. 66666
	4	7. 2			4	2. 22222
	5	9. 0			5	2. 77777
	6	10. 8			6	3. 33333
	7	12. 6			7	3. 88888
	8	14. 4			8	4. 44444
	9	16. 2			9	4. 99999

Réaumur degrees into Fahrenheit.				Fahrenheit degrees into Réaumur.		
		Fahrenheit degrees.				Réaumur degrees.
Réaumur degrees	1	2. 25	+32	Fahrenheit degrees—32	1	0. 44444
	2	4. 50			2	0. 88888
	3	6. 75			3	1. 33333
	4	9. 00			4	1. 77777
	5	11. 25			5	2. 22222
	6	13. 50			6	2. 66666
	7	15. 75			7	3. 11111
	8	18. 00			8	3. 55555
	9	20. 25			9	4. 00000

TABLE N.—*Units of heat.*

Metrical into United States.			United States into metrical.		
		United States units of heat.			Metrical units of heat.
Metrical units of heat (calorie).	1	3. 96831835	U. S. units of heat	1	0. 25199593
	2	7. 93663670		2	0. 50399186
	3	11. 90495505		3	0. 75598779
	4	15. 87327340		4	1. 00798372
	5	19. 84159175		5	1. 25997965
	6	23. 80991010		6	1. 51197558
	7	27. 77822845		7	1. 76397151
	8	31. 74654680		8	2. 01596744
	9	35. 71486515		9	2. 26796337

APPENDIX 28.

DETERMINATION OF THE ACCURACY OF SMALL-ARM FIRING.

(Three plates.)

FRANKFORD ARSENAL,
March 31, 1880.

SIR: In accordance with your instructions to consider some ready graphical determinations of the accuracy of small-arm firing, I have the honor to report that I have discovered a more prompt and accurate method of computation than even the excellent plan devised and described by Captain Prince in Ordnance Memorandum No. 8, p. 38.

Notwithstanding its simplicity, this requires about half an hour's time to compute an ordinary mean absolute deviation, which even then, in spite of the proving system devised by Captain Prince, may be wrong; and which, though I hesitate to assert it, when obtained is only an approximate and imperfect measure of the accuracy of fire.

These seem rash assertions, but they can be proved by referring to a recent experience of my own.

I had to compute a dozen targets of ten shots each, from firing Lowell ammunition in comparison with the service.

Although in doing this both my assistant and myself were experienced in the work, the two following errors were made, neither of which would have been discovered but for comparison with the process to be described further on.

In the first place, in measuring or in setting down the position of one of the shots, its co-ordinate was called 8.75 when it should have been 7.75. This mistake is found in practice not unusual, but it is a grave one, since the measured co-ordinates so transcribed become the basis of the entire computation, being no longer checked by reference to the target diagram. This diagram, being the photographic reproduction of the target, is to all intents the target itself, as far as measurements are concerned.

Besides this cause of error, there is another one of computation which is so involved with the proof as to escape detection. An example is shown in the target record sent herewith, in which the mean horizontal deviation is obtained by the following operation $(42.85-37.68)\div5=1.03$; and the operation is proved as follows, viz: $(-19.95+25.12)\div5=1.03$.

But if, as happened to me once, we happen to put down the product of the "C of I by No. of ± co-ordinates" in the wrong place, the *proof* still seems to come out right, viz: $(42.85-25.12)\div5=3.54$; or for proof $(-19.95+37.68)\div5=3.54$, which seems to be correct, but is really wrong.

This failure of the proof does not always obtain; but it may frequently occur that results are obtained by this inversion which are so nearly alike that their differences may readily be attributed to the neglect of remote decimals in the preliminary computations.

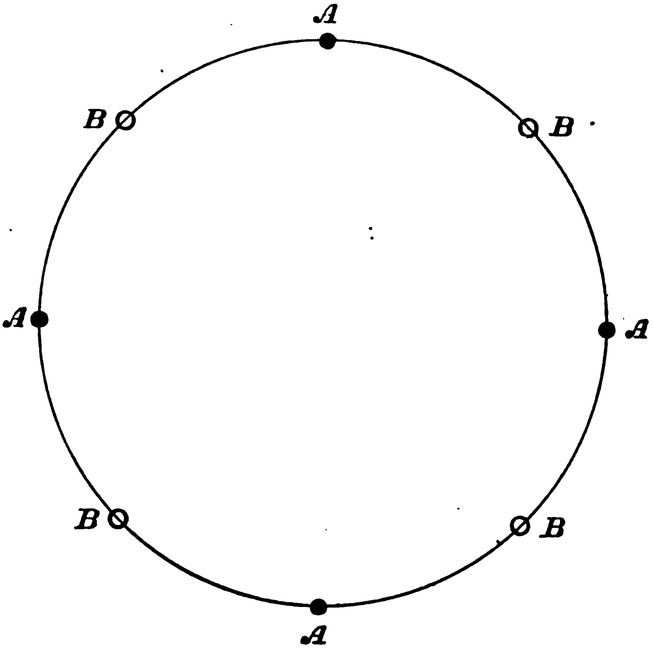
Granting the correctness of the computations of the mean vertical and horizontal deviations, which are undoubted aids in analyzing causes of inaccuracy, we proceed ordinarily to combine them in the mean absolute deviation as the (inverse) measure of accuracy. It is to this quantity that our attention is generally confined.

The mean absolute deviation is graphically the hypothenuse of a right-angled triangle, of which the co-ordinate deviations are the sides.

Without considering the absurdity of calling that an absolute quantity which is capable of expressing the relation between an infinite number of the co-ordinate deviations on which it alone depends, since the same hypothenuse will satisfy any value of the co-ordinate from ($x=0$; $y=a+b$) to ($y=0$; $x=a+b$), the question remains as to what we have at last obtained as the fruit of a really considerable labor.

I reply, a quantity which has no meaning except as an obscure relation between two valuable and independent measures, the importance of which is generally lost sight of in the specious convenience of the result. Is it not a mistake to have that as a measure which can only be explained by first defining two other quantities and then describing it as the way of expressing *one* of the relations between them? As if one were required to form an idea of a certain ellipse only from the length of the chord joining the extremities of its principal axes.

I confess to an error, p. 29, descriptive pamphlet U. S. small arms, where the mean absolute deviation is defined as the average distance of the shot marks from the center of the cluster which they form.* This is properly the mean radial deviation or the "string" referred to its new origin.* From the natural dispersion of the shots this happens to be often nearly equal to the "mean absolute deviation," though bearing no constant relation to it.



The effective difference in the two systems of measurement may be seen by considering the two supposititious targets of four shots each below. In both cases every shot is supposed to be at one foot from the center of impact. In case A they are arranged on the vertical and horizontal axes, and in case B on their diagonals.

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* NOTE, 1882.—This is now termed the "radius of the circle of shots."

Now these targets are to all intents, as far as hitting a distinct object is concerned, the same, and one would say as the measure of either target that the shots struck on the average (in these cases invariably) within a foot of the center of impact, or that their mean radial deviation was one foot.

But instead, the mean absolute deviation of target A is now determined as follows: we say that as its mean vertical deviation is $\frac{1+1}{4}=\frac{1}{2}$, and its mean horizontal deviation the same; therefore the mean absolute deviation is

$$=\sqrt{(\tfrac{1}{2})^2+(\tfrac{1}{2})^2}=\sqrt{\tfrac{1}{4}+\tfrac{1}{4}}=\sqrt{\tfrac{1}{2}}=0.70+$$

Now in target B the mean vertical and horizontal deviations are also evidently equal to each other, and each $=\frac{2.8}{4}=0.7=\sqrt{\frac{1}{2}}$, hence the mean absolute deviation of target B $=\sqrt{\frac{1}{2}+\frac{1}{2}}=1$, which is 43% greater than the same measure for the precisely similar target A.

In the case of target B the mean absolute and mean radial deviations are equal to each other. So it appears that according to the present system the value of the target is affected by the way in which we look at it, or by the position of the axes to which it is referred.

The action of the force of gravity naturally determines one of these directions, and hence that of the other axis; this is right so long as they are separately considered, but they cannot properly be combined.

The use of the little measuring wheel or opisometer, figured and described in Ordnance Note 85 (Plate IV, p. 681*), serves to save much labor and time in the computation and to make it more accurate; for, as before said, all errors of transcription are eliminated, the result being the same as if the target itself were measured every time.

With a wheel much cruder in design I have been able to compute, in five minutes, targets which took experienced calculators half an hour; and in so doing to correct each of the errors of the ordinary method above described as likely to occur.

Since the camera giving the target diagram is so adjusted as to give an image $\frac{1}{12}$th that of the target, and since the measuring wheel is divided to a decimal scale of inches, it follows that the readings of the measuring wheel may be taken as those of the target on a decimal scale of feet.

The operation of the wheel is as follows: With the wheel set at 0, place the pointer, say on shot marked No. 6 of the target diagram herewith, and run the wheel down to the horizontal line No. 7, as shown by the dotted lines. Lift the wheel from the paper and repeat the operation on shots No. 10, No. 8, and so on in succession, calling 1, 2, 3, &c., as you go on, so as to make sure of measuring them all. When this is done add the reading of the wheel, in this case $=26''.2$, to 10 times $7''$; the sum divided by 10 gives $9''.62$, which is the vertical co-ordinate of the center of impact referred to the principal axes of the target. The difference between this and the corresponding vertical co-ordinate of the point aimed at (not necessarily the center of the target) gives the vertical *deflection*. To prove the operation, turn the paper 180° and run the wheel from each shot-mark down to horizontal line No. 12. The reading, which should be 23''.8 added to 10 times 3'', will give 10 times the complement of the first co-ordinate; or else, as it is an entirely independent process, repeat the operation.

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*Also Report Chief of Ordnance U. S. A., 1878, p. 139.

To get the horizontal co-ordinate of the center of impact, repeat the same operation horizontally from each shot-mark successively to the vertical line No. 4. The sum of these distances = 22''.8, to which add 10 × 4'' = 40'' and divide by 10, and you get 6''.28 for the horizontal co-ordinate of the center of impact, from which the horizontal *deflection* can be arrived at as before for the vertical deflection.

Having thus determined the position of the center of impact, plot it, and run the wheel from each shot to the center; the final reading divided by the number of shots will give the *mean radial deviation.*

The mean vertical and horizontal deviations may be obtained by drawing horizontal and vertical axes through the center of impact, and then taking with the wheel the sum of the distances of the shot-marks above *and* below the horizontal axis, and to the right *and* left of the vertical axis respectively. For an ordinary target of 10 shots these distances can be laid off directly by running the wheel backwards over the boundary line of the diagram from the origin along the axes of x and y respectively, after each series of measurements above described.

By joining the points where the wheel stops by a straight line we obtain a graphical representation of the mean absolute deviation, which, measured by the wheel, gives that quantity directly, multiplied by 10. This process avoids errors of reading and computation and is more rapid than figuring each co-ordinate variation separately. It has also been found very useful as a ready demonstration to the eye, while running over a large number of target diagrams, of the principal causes of deviation. For example, in a series of comparative firing between two kinds of ammunition, the accuracy in each case being practically the same, the fact that in one series this line made a notably more acute angle with the axis of y than it did in the other series, showed at once that its inaccuracy was largely due to inequality in the powder, afterwards found to result from its deterioration by the melting of the lubricant.

It is needless to say that instead of the wheel a paper tape may be used; also that, instead of referring the center of impact to the edges of the target, any nearer origin may be taken.

The former method of reference is preferred, as in practice it can be applied with less risk of error in tabulating the results of the computation, particularly if the co-ordinate deflections of the center of impact from the point aimed at be considered in their relation to the effects of wind and weather.

I submit herewith one of Captain Prince's forms of target record filled up, to show the figuring which the method I propose is intended to save; this record applies to the same target diagram heretofore referred to. Also a table showing the relation between the present method of computation and that which is proposed for a certain number of actual targets. This shows that while there is no fixed ratio between the two measures for the same target, the new method will be about 10 per cent. numerically greater.

In conclusion, I would say the principal advantage of the method of direct measurement herewith proposed consists in the encouragement its simplicity affords to the frequent direct testing of the accuracy of our daily product of ammunition, instead of the inferential determination of this quality from the uniformity of its initial velocity and its other ballistic properties.

BENICIA ARSENAL, *May 2*, 1882.

I append herewith an interesting mathematical discussion by Capt. O. E. Michaelis on the relation between the mean absolute deviation and that above proposed and now adopted under the name of the radius of the circle of shots; also a description of the method of constructing the target mask referred to in Ordnance Note 171.

The completion of the above matters has been delayed for a year by my sickness.

Very respectfully, your obedient servant,

HENRY METCALFE,
Captain of Ordnance.

Co-ordinates from target diagram No. 14, March 26, 1880.—(Prince's Method.)

	Vertical.	Horizontal.			
Shot No. 1	8.35	+8.45			
Shot No. 2	+9.65	+7.45			
Shot No. 3	+11.20	+6.55			
Shot No. 4	+10.90	+7.70			
Shot No. 5	+11.10	5.70			
Shot No. 6	9.40	4.25			
Shot No. 7	+10.90	+6.40			
Shot No. 8	7.70	5.00			
Shot No. 9	8.55	+6.30			
Shot No. 10	8.45	5.00			
Footing	96.20	62.80			
Divided by 10 = center of impact	9.62	6.28	9.62	6.28	Co-ordinates of center of impact.
Footing of + co-ordinates*	53.75	42.85	7.50	7.50	Co-ordinates of point sighted.
C. of I. × number of + co-ordinates	48.10	37.68	2.12	1.22	Differences = deflections.
Difference ÷ 5† = mean deviation	1.13	1.03			
Proof: Footing of — co-ordinates	42.45	19.95			
C. of I. × number of — co-ordinates	48.10	25.12			
Difference ÷ 5‡ = same as above	1.13	1.03			
Square of mean vertical deviation	127.69				
Square of mean horizontal deviation	106.69				
Sum of the squares	233.78				
Square root of sum of the squares or mean absolute deviation	1.53				

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* The plus co-ordinates exceed the co-ordinates of center of impact; all others are minus.

† Or half the number of shots.

‡ The subtension in minutes per foot of 800 and 500 yard targets respectively.

Comparison of both methods from practice, March 26, 1880.

Day No. of target.	Ammunition.	Center of impact.		Mean deviation.				Corresponding ratio of radial to absolute deviation.
		V.	H.	Vertical.	Horizontal.	Absolute.	Radial.	
7	A	11.73	7.85	0.49	0.85	0.98	1.07	1.09
8	B	9.20	8.74	1.09	1.17	1.60	1.78	1.11
9	B	11.06	7.12	0.83	1.08	1.36	1.58	1.16
10	B	9.47	8.33	1.28	1.08	1.68	1.87	1.11
11	B	10.05	7.34	1.05	1.08	1.50	1.63	1.09
12	B	10.12	7.30	1.52	1.29	1.99	2.23	1.12
13	A	10.52	7.46	0.56	0.89	1.05	1.13	1.08
14	B	9.62	6.28	1.13	1.03	1.53	1.69	1.10
15	B	9.72	5.37	0.58	0.97	1.13	1.23	1.09
16	B	9.76	7.43	0.88	1.23	1.51	1.65	1.09
17	B	10.42	6.66	1.08	1.43	1.79	1.95	1.09
18	A	11.85	6.61	0.85	0.77	1.15	1.35	1.16

APPENDIX I.

INVESTIGATION OF THE RELATIVE VALUES OF R, CALLED "THE RADIUS OF THE CIRCLE OF SHOTS," AND D, CALLED THE MEAN ABSOLUTE DEVIATION.

Let $R_1\ R_2 : \ldots\ldots R_s$ represent the distances of the individual shots from the "center of shots;" $x_1\ x_2 \ldots\ldots x_s$, $y_1\ y_2 \ldots\ldots y_s$ their rectangular co-ordinates, or the horizontal and vertical deviation or error of each shot, s the number of shots, we have then—

$$(1)\quad R=\frac{R_1+R_2\ldots\ldots+R_s}{s}=\frac{\Sigma\sqrt{x^2+y^2}}{s}$$

$$(2)\quad D=\frac{\sqrt{(x_1+x_2\ldots\ldots+x_s)^2+(y+y_2\ldots\ldots+y_s)^2}}{s}=\frac{\sqrt{(\Sigma x)^2+(\Sigma y)^2}}{s}$$

An inspection of these expressions shows that R, "the radius of the circle of shots," or "the mean distance from center of impact," is also the "mean absolute deviation;" and that D is the mean *geometric* deviation, for it is simply the hypothenuse of a triangle whose sides are respectively the mean horizontal and vertical deviations. In this sense these expressions are used in the Aide-Memoire and by von Plœnnies, the continental authorities, and in our own "Small Arms," 1856, pp. 19–24; the term "mean absolute variation" is also applied correctly.

Squaring equations 1 and 2, we have—

$$\begin{aligned}
s^2 R^2 &= \Sigma(R_1)=R_1^2+R_2^2\ldots+R_s^2+\Sigma 2\,(R_s\,R_1),\\
s^2 D^2 &= x_1^2+x_2^2\ldots+x_s^2+y_1^2+y_2^2\ldots+y_s^2+\Sigma\,(2\,x_s\,x_1)+\Sigma\,({}^2y_s\,y_1),\\
&= R_1^2\,R_2^2\ldots R_s^2+\Sigma\,(2\,x_s\,x_1)+\Sigma\,(2\,y_s\,y_1),
\end{aligned}$$

in which Σ represents the sum of similar quantities. Hence—

$$(3)\qquad s^2 R^2-s^2 D^2=\Sigma\,(2\,R_s\,R_1)-\big(\Sigma\,(2\,x_s\,x_1)+\Sigma\,(2\,y_s\,y_1)\big).$$

Now if $\Sigma\,(2\,R_s\,R_1)>\Sigma(2\,x_s\,x_1)+\Sigma\,(2\,y_s\,y_1)$, it follows, of course, that $R>D$.

But this is true provided each term of the series $\Sigma\,(R_s\,R_1)$ is greater than the sum of the corresponding terms of the series $\Sigma\,(x_s\,x_1)$ and $\Sigma\,(y_s\,y_1)$, respectively. We should have, therefore—

$$(4)\qquad R_1\,R_2>x_1\,x_2+y_1\,y_2.$$

But

$$\begin{aligned}
R_1^2\,R_2^2 &= (x_1^2+y_1^2)\,(x_2^2+y_2^2)\\
&= x_1^2\,x_2^2+x_1^2\,y_2^2+x_2^2\,y_1^2+y_1^2\,y_2^2;
\end{aligned}$$

adding and substracting $2\,x_1\,x_2\,y_1\,y_2$, we have—

$$(5)\quad R_1^2\,R_2^2=x_1^2\,x_2^2+2\,x_1\,x_2-y_1\,y_2+y_1^2\,y_2^2+x_1^2\,y_2^2-2\,x_1\,x_2\,y_1\,y_2+x_2^2\,y_1^2,$$

in which the arrangement of the terms is arbitrary; hence—

$$(6)\qquad R_1\,R_2=\sqrt{(x_1\,x_2+y_1\,y_2)^2+(x_1\,y_2-x_2\,y_1)^2}.$$

$$=(x_1\,x_2+y_1\,y^2)\sqrt{1+\frac{(x_1\,y_2-x_2\,y_1)^2}{(x_1\,x_2+y_1\,y_2)^2}};$$

hence $R_1 R_2 > x_1 x_2 + y_2 y_2$, and as this is general, we have—

$$\Sigma(R_s R_1) > \Sigma(x_s x_1) + \Sigma(y_s y_1), \tag{7}$$

and, of course,

$$R > D.$$

When

$$\frac{x_1 y_2 - x_2 y_1}{x_1 x_2 + y_1 y^2} = O \text{ in (6), then—}$$

$$R_1 R_2 = x_1 x_2 + y_1 y_2, \text{ and } D = R;$$

and this occurs when the shots lie on the same radius sector for—

$$\frac{x_1 y_2 - x_2 y_1}{x_1 x_2 + y_1 y_2} = \frac{\frac{y^2}{x^2} - \frac{y^1}{y^2}}{1 + \frac{y_1 y_2}{x^1 x^2}} = O;$$

$$= \frac{\tan \alpha - \tan \beta}{1 + \tan \alpha \tan \beta},$$

when β and α are the angles made by R_1 and R_2 with the axis. Hence—

$$\tan(\alpha - \beta) = O, \text{ and}$$
$$\alpha = \beta.$$

As this special case can never arise in practice, it follows that the "radius of the circle of shots" is always greater than what we have latterly called the "mean absolute deviation."

Equation (3) shows that only in one case does the difference between R and D become a minimum, and that occurs when they are equal; but that it can never become a maximum, for both R and D are functions of x and y, and $\Sigma(2\,x_s x_1) + \Sigma(2\,y_s y_1)$ can be zero only when x and y are zero, which, of course, also makes R and D zero.

O. E. MICHAELIS,
Captain of Ordnance.

To Capt. HENRY METCALFE,
Ordnance Corps.

APPENDIX II.

DESCRIPTION OF THE METHOD OF CONSTRUCTING A MASK FOR THE FIRING GROUND AT FRANKFORD ARSENAL.

The necessity of some such contrivance arose when a citizen, while in a boat upon the Delaware River some 30° out of the plane of fire, was accidentally shot. The marksman was firing at a temporary target in line with the main iron target, but the last shot of a series of 20 glanced from one of the uprights, and, after going 200 yards, pierced obliquely the unfortunate fisherman's thigh.

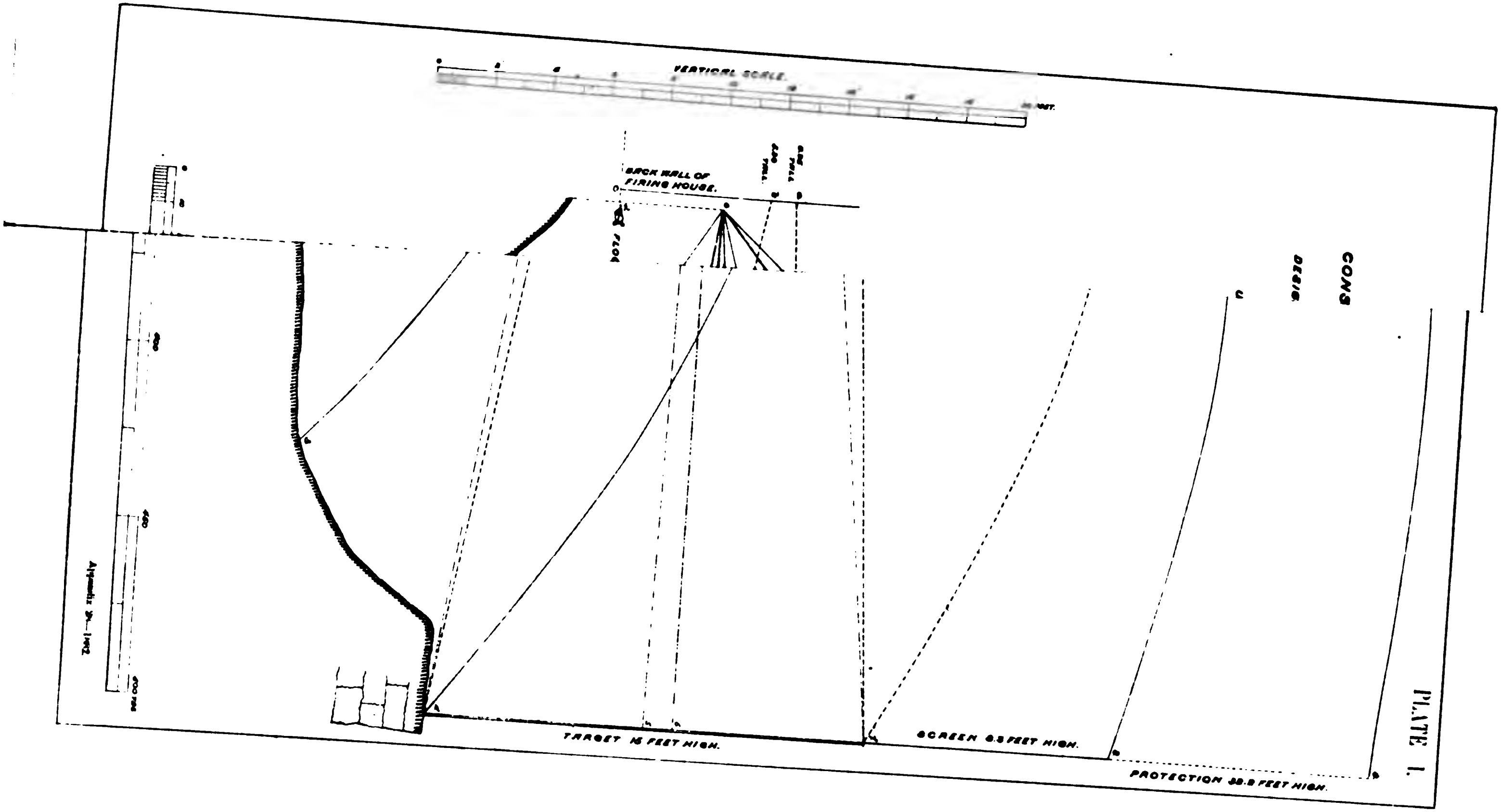
To make the firing perfectly safe, therefore, it was required to provide means of intercepting all bullets, except those which would certainly hit the target, and to do this without limiting any existing conveniences. The readiest mode of doing this was by the use of an iron mask or shield provided with proper ports for aiming through and for the passage of the bullets. It was constructed and placed as follows:

Templets, representing the trajectories of the rifle and carbine, were constructed from official data and used as follows: Differences in convexity due to excessive elevations were neglected. [Plate I.] A profile line was run from *e*, the muzzle of the gun in the fixed rest, to the 500-yard target 4.7. From *e* was drawn the carbine trajectory *e* 7 and the rifle trajectory *e* 4. On the line *a c*, representing the back wall of the firing-house, was laid off *c b*=5 feet, representing the eye of a person say 5′.30 tall. From this *b* 4 was drawn intersecting trajectory *e* 4 at *h*. This gives the distance of the mask from the firing point, for by construction the shortest spectator standing in the most unfavorable portion of the firing-house behind the firer can still observe the effect of the fire through the aperture above *h* left for the passage of the bullets.

Drawing the vertical line *m h f* gives the intersection *g*, and the line 7 *g* prolonged strikes the back wall at *a*, allowing a spectator 6′.25 tall the same convenience as before.

This aperture *g h*, therefore, allows the passage of all bullets to any point of the target from the flattest trajectory—that of the rifle—to the most curved one—that of the carbine; and also affords as good a view of the result of the fire as can be desired. Then the mask can be extended vertically to *f* and *l*, and also horizontally, as far as is thought necessary for safety. All bullets fired from *e* must then either strike the target or be stopped by the mask. But, as by accident, a rifle bullet might be fired through the hole, just grazing the upper edge at *g*, and hence passing over the upper edge of the target beyond, the target is extended vertically by a light iron screen, 7.8, projected to meet the rifle trajectory *e g* 8, and the protection vertically is complete. The straight lines *e* 4 and *e* 7 determine the aiming port. As the target is square, this, too, will be square, and the width of the target will prescribe the width of the port of which *g h* is the height. The trajectories *e* 1, *e* 2, *e* 3, *e* 9 show the protection afforded by the limits of the mask. The ground is marshy from 1 to 4, and the trajectories at 1, 2, and 3 are approximately normal to its surface, hence bullets at these points are not likely to glance; otherwise small traverses or terraces would be put in or the ground plowed.

Plate III shows the front view of the mask. The holes or ports are faced with pieces of half-inch iron one foot wide and beveled on their inner edges. These overlap slightly the edges of the main plates to further protect them. If frequently struck they can be easily renewed without interfering with the main construction. The whole mask is mounted on a stout wooden frame, to which it is hinged at 90° to the plane of fire, so that in case of an extraordinary necessity it can be lowered out of the way. A table is arranged to be laid upon the fixed rest in shoulder firing with muzzle rest, so that the muzzle of the piece will always be practically at *e*.



Appendix 24—1882

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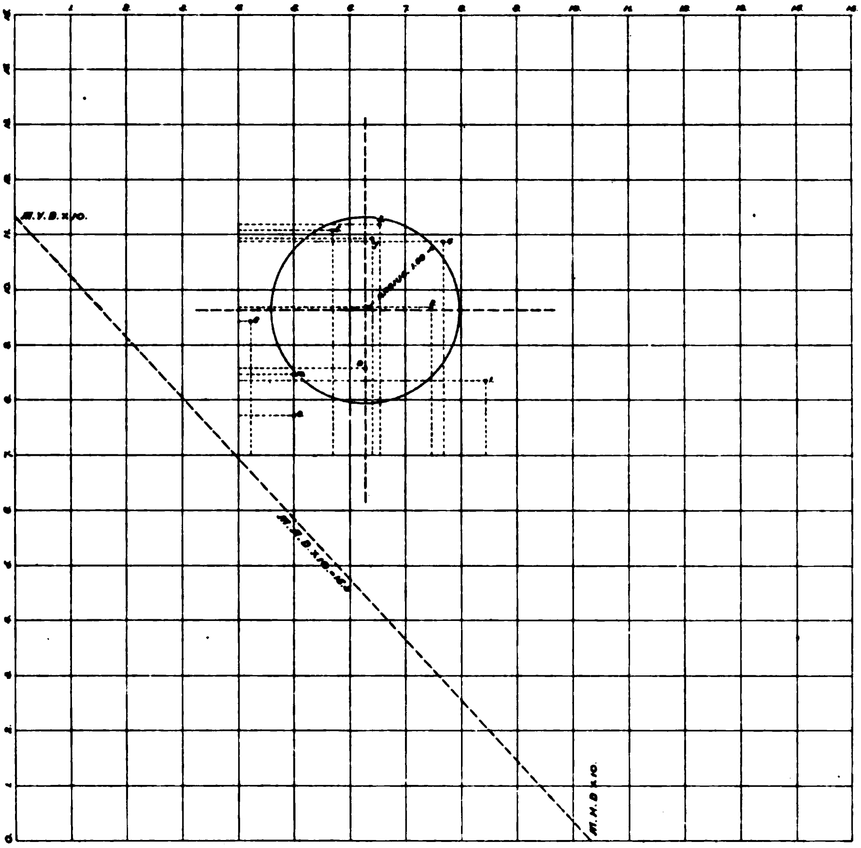
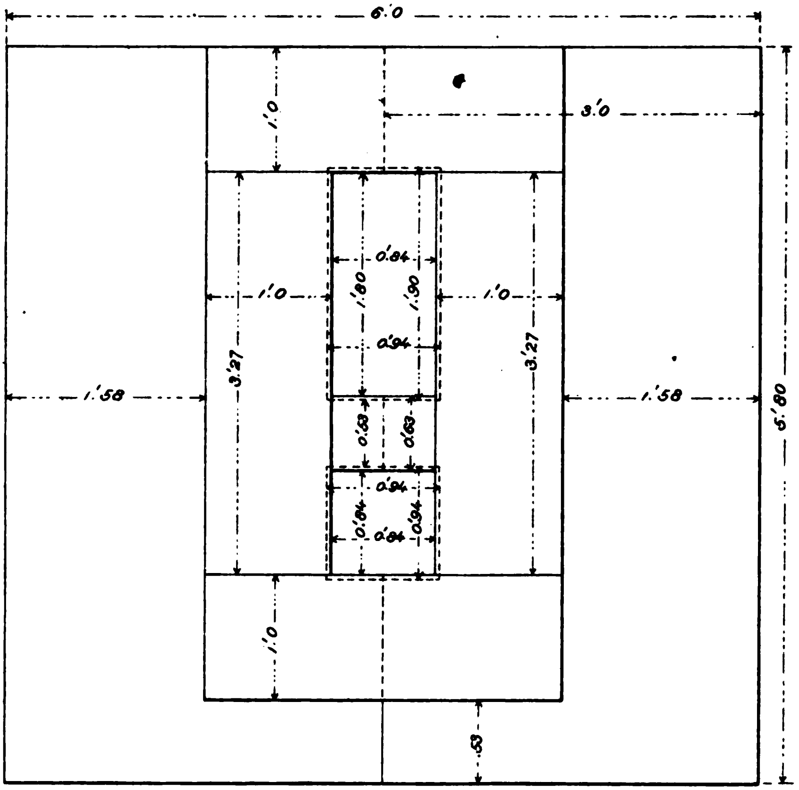
PLATE II.

500 YARDS TARGET.



MASK FOR 500 YARD TARGET



APPENDIX 29.

REPORT ON CRANSTON'S SAFETY LIGHTING ATTACHMENT FOR LANTERNS FOR THE LIFE-SAVING SERVICE.

BY CAPT. D. A. LYLE, ORDNANCE DEPARTMENT.

(One plate.)

This attachment is the invention of Mr. J. F. Cranston, of the National Armory, Springfield, Massachusetts, who has recently patented it.

NOMENCLATURE.

(*Plate I, Fig.* 7.)

This device consists of four pieces, viz:

1. The gate;
2. The igniter;
3. The assembling screw;
4. The rubber washer.

The gate, igniter, and assembling screw are made of brass.

DESCRIPTION.

1. *The Gate* (Fig. 6).—This is punched from sheet-brass and has a hole at its larger end that fits a shoulder on the under side of the head of the assembling screw. It rotates upon this shoulder as an arbor. The lower end has a projection on its under side which enters the lower hole in the glass globe and prevents lateral motion when the gate is closed. The thumb piece is formed by curving upward the lower end of the gate.

2. *The Igniter* (Figs. 1, 2, 3, and 7).—This is punched from sheet-brass. The circular hole near the upper end has a female-screw thread cut upon its interior surface which engages the male thread of the assembling screw. The front side of the igniter is a coarse double-cut file surface, upon which the friction-matches are ignited. To prevent the filling up of the cuts with brimstone three rectangular notches are made at the lower end. After being prepared as shown in Fig. 3, the igniter is bent as shown in Fig. 7.

3. *The Assembling Screw* (Fig. 5).—This screw is made from brass wire. The head is rounded and slotted for a screw-driver. The under side of the head has a cylindrical shoulder upon which swings the gate. The body has a male-screw thread to engage a corresponding female thread in the igniter.

4. *The Rubber Washer* (Fig. 4).—This is cylindrical and has an axial hole through which the assembling screw passes.

ASSEMBLING.

The glass globes are prepared by drilling two holes through the side at the proper distance apart. The centers of these holes are approximately in a vertical plane.

Having the components prepared, pass the assembling screw through the hole in the gate and then through the upper hole in the glass globe. Slip the rubber washer on from the inside, and then holding the igniter in position turn the screw in with the fingers and tighten with a screw-driver. The file cut surface coming in contact with the washer will prevent lateral motion of the igniter, and at the same time the washer will yield enough during expansion and contraction to prevent the breaking of the glass globe.

ACTION.

To light or relight a lantern fitted with this attachment press the thumb-piece toward the right, carrying the gate clear of the lower hole in the glass globe. Insert the friction-match, press it against the igniter, and with a brisk downward motion of the composition end the match will be ignited by friction against the file cut surface. Pause a moment until the match is well lighted, and then extend it until it reaches the wick. After igniting the wick the match may be dropped inside the lantern, thus avoiding any danger from fire that might occur from throwing away an unextinguished match after using; or, by withdrawing it slowly the match will be extinguished in passing through the hole in the glass globe.

USES.

Lanterns fitted with this attachment are intended for use in stormy or wet weather. As long as the matches are kept dry there is no difficulty in lighting the lantern no matter how windy it may be.

LIFE-SAVING SERVICE.

For this service the device is intended to be attached to the patrol lanterns, and, if required, to all lanterns at the stations. Patrolmen on tempestuous nights often have their lanterns extinguished by the wind, whereas the application of this simple arrangement would enable them to relight their lanterns without delay.

MILITARY SERVICE.

Stable lanterns, battery lanterns, company lanterns, and those of watchmen in and around public buildings, such as stables, shops, arsenals, commissary and quartermaster store-houses, can be fitted with it so as to avoid danger from fire, not to mention the ease of lighting out doors in windy weather.

RAILWAY SERVICE.

Here it has already shown itself to be a valuable auxiliary to the safety of trains. In case of delay or accident, where a brakesman jumps from his train to go to the front or rear to signal an advancing train, it frequently happens that his light is extinguished by the act of jumping down. If very windy, great difficulty is experienced in relighting it. This delay may be sufficient to cause a collision that would otherwise have been prevented by the employment of such a device.

APPENDAGES.

The wick-picker is a pointed steel wire used for raising and adjusting the wick of the lantern. It is inserted through the hole in the globe. A match-box or safe can be attached to the outside of the lantern if desired.

COST.

The cost of the attachment is twenty cents for each lantern. When lanterns fitted with this device are ordered the ordinary price of the lantern must be added to the above.

EXPLANATION OF PLATE.

Plate 1.

Fig. 1. Elevation and partial section of lantern, showing method of using Cranston's "Safety lighting attachment."

I.—Igniter (sheet brass).
W.—Rubber washer.
S.—Assembling screw (brass).
P.—Wick-picker.
M.—Lighted friction-match.
O.—Hole in glass globe.

Fig. 2. Front elevation of Cranston's "Safety lighting attachment' for lanterns:

AA.—Segment of glass globe.
S.—Assembling screw (brass).
G.—Gate (brass).
I.—Igniter.
O.—Hole in glass globe.

Fig. 3. Igniter before bending:

H.—Hole for assembling screw.

Fig. 4. Rubber washer:

A.—End elevation.
B.—Side elevation.
C.—Hole for assembling screws.

Fig. 5. Assembling screw:

A.—Side elevation.
B.—End elevation.
C.—Shoulder for gate.

Fig. 6. Gate (brass):

H.—Hole for shoulder of assembling screw.
L.—Projection to hold gate in place when closed.
T.—Thumb-piece of gate.

Fig. 7. Safety lighting attachment:

A A.—Section of glass globe.
H.—Hole for assembling screw.
O.—Hole for inserting friction-match.
S.—Assembling screw.
W.—Rubber washer.
I.—Igniter.
G.—Gate.
T.—Thumb-piece of gate.
L.—Projection on under side of gate to hold it in position when closed.

Fig. 8. Wick-picker (steel wire).

PLATE I.

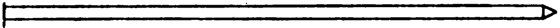


Fig. 8.

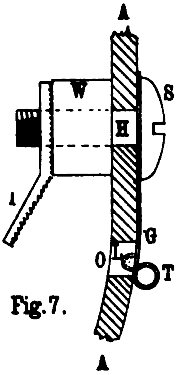


Fig. 7.

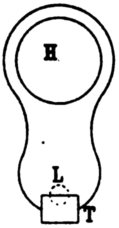


Fig. 6.

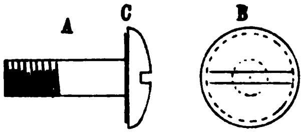
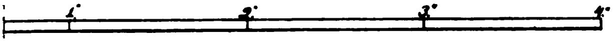


Fig. 5.



LIFE-SAVING APPARATUS.

CRANSTON'S
SAFETY-LIGHTING ATTACHMENT
FOR
LANTERNS.
DESIGNED FOR
Life-Saving Service, Railways, &c.

1882.

Appendix 29—1882.

APPENDIX 30.

REPORT OF THE BOARD ON MAGAZINE GUNS.

(20 plates.)

OFFICE OF BOARD ON MAGAZINE GUNS,
ARMY BUILDING,
New York City, September 29, 1882.

SIR: I have the honor to forward herewith the report of the Board on Magazine Guns, with the journal of proceedings.

The models of guns recommended, with drawings, descriptions, and synopses of tests, will be forwarded to-morrow by mail and express.

I am, sir, respectfully, your obedient servant,
JOHN R. BROOKE,
Col. Third Infantry, President of Board.

THE ADJUTANT-GENERAL U. S. ARMY,
Washington, D. C.

REPORT OF THE BOARD.

ARMY BUILDING, NEW YORK CITY,
September 5, 1882.

In compliance with General Orders No. 31, from Headquarters of the Army, Adjutant-General's Office, Washington, D. C., March 21, 1881, and Special Orders No. 98, from Headquarters of the Army, dated Adjutant-General's Office, Washington, D. C., April 29, 1881, and Special Orders No. 117, dated McPherson Barracks, Atlanta, Ga., July 5, 1881, the Board met and has continued in session, except during authorized adjournments, up to the present time.

The Board has given careful consideration to all guns brought before it, and has applied the tests in as uniform a manner as practicable, and has at all times as carefully considered the interests of all concerned as circumstances would permit, and it takes pleasure in acknowledging the assistance of manufacturers and inventors.

The regulations for tests of arms are given in the Appendix.

The Lee gun, No. 36, the Chaffee-Reece, No. 33, and the new Hotchkiss, No. 34, representing the different systems of the detachable and fixed magazines, and having passed these tests in a satisfactory manner, and possessing, in a remarkable degree, efficiency as single loaders, and considering safety, ease of loading, rapidity of fire, endurance, moderate weight, and simplicity of construction, are, in the opinion of the Board, suitable for the military service, and it does recommend them in the order named.

On account of novel and meritorious features of the Spencer-Lee, No. 35, and its record made before the Board, especially for rapidity with accuracy, it is recommended that the manufacturers be invited to produce models embodying suggestions of the Board as to weight, &c., and to submit them to the War Department with a view to a trial of a limited number in service.

JOHN R. BROOKE,
Colonel Third Infantry.
F. W. BENTEEN,
Captain, Seventh Cavalry.
GEO. SHORKLEY,
Captain, Fifteenth Infantry.
H. G. LITCHFIELD,
Captain, Second United States Artillery.
JOHN E. GREER,
Captain of Ordnance, United States Army.

S. A. DAY,
First Lieutenant, Fifth Artillery, U. S. A., Recorder.

HEADQUARTERS OF THE ARMY,
Washington, D. C., September 30, 1882.

Respectfully submitted to the honorable Secretary of War. I construe this report to mean this: Of all the patent inventions which have been thrust on the attention of the War Department, the Congress, and the country, only three meet the tests pre-established by the Board, viz:

1st. The Lee gun, No. 36.
2d. The Chaffee-Reece, No. 33.
3d. The new Hotchkiss, No. 34.

The Spencer-Lee, No. 35, seems to possess some novel features, which ought to be encouraged, but it does not come into the present contest, which is "that fifty thousand dollars of an existing appropriation may be expended in the manufacture of magazine guns to be selected by a board of officers," &c.

Under and by virtue of this report I advise the honorable Secretary of War to contract for fifty thousand dollars' worth of the Lee gun, No. 36; that one each of the Chaffee-Reece, the new Hotchkiss, and of the Spencer-Lee be bought and deposited in the Museum of Arms in the Ordnance Department at Washington; and that official copies of this report be furnished the owners or agents of the four guns herein enumerated, to be used by them for what it is worth in their private business.

W. T. SHERMAN,
General.

Respectfully referred to the Chief of Ordnance, who will please examine the three guns recommended by the within-mentioned Board, and all the papers in the case, and make report as to what is shown by the record as to the comparative merits of the three guns mentioned.

Any remarks which the Chief of Ordnance may desire to submit are invited.

By order of the Secretary of War.

JOHN TWEEDALE,
Chief Clerk.

WAR DEPARTMENT, *October* 5, 1882.

ORDNANCE OFFICE, WAR DEPARTMENT,
Washington, October 9, 1882.

Respectfully returned to the Secretary of War. A careful examination of the report and accompanying papers convinces me that the merits of the three guns in the order recommended by the Board are fully borne out by the records, and that, while the Lee gun is entitled to the first place, the comparative merits of the three guns put them nearly on a par in point of excellence,

Representing, as they do, different systems of magazine mechanism, and believing that a competitive trial will give interesting, valuable, and practical results, and that we have the means of providing a sufficient number of the three guns for a fair and exhaustive trial, I respectfully recommend that the fifty thousand dollars available for the "manufacture or purchase of magazine guns, to be selected by the board of officers heretofore appointed by the Secretary of War," be expended in providing the Lee, the Chaffee-Reece, and the Hotchkiss magazine guns, for trial in the hands of troops.

S. V. BENÉT,
Brigadier-General, Chief of Ordnance.

WAR DEPARTMENT,
October 9, 1882.

Respectfully returned to the Chief of Ordnance.

The foregoing recommendation made by him is approved. He will proceed to ascertain at what prices the three guns mentioned can be procured, either by manufacture or otherwise, and upon making report thereof, the number of each kind of gun to be procured will be determined.

ROBERT T. LINCOLN,
Secretary of War.

Proceedings of a Board of Officers convened by virtue of the following orders:

[General Orders No. 31.]

HEADQUARTERS OF THE ARMY,
ADJUTANT-GENERAL'S OFFICE,
Washington, March 21, 1881.

The following order from the War Department is published for the information of all concerned:

The "act making appropriations for the support of the Army for the fiscal year ending June 30th, 1882, and for other purposes," approved February 24, 1881, contains the following:

> For manufacture of arms at national armories, three hundred thousand dollars: *Provided*, That not more than fifty thousand dollars of this amount may be expended by the Secretary of War in the manufacture or purchase of magazine guns, to be selected by a board of officers to be appointed by the Secretary of War.

In conformity with the foregoing act, a Board of Officers will assemble at the Army Building, New York City, on the 5th day of July, 1881, to examine and consider all the magazine guns that may be brought before it, and recommend such (one or more) of these guns as, in its judgment, are suitable for the military service.

DETAIL FOR THE BOARD.

Col. R. I. Dodge, aide-de-camp (lieutenant-colonel Twenty-third Infantry).

Capt. F. W. Benteen, Seventh Cavalry.

Capt. George Shorkley, Fifteenth Infantry.

Capt. H. G. Litchfield, Second Artillery.

Capt. John E. Greer, Ordnance Department.

Capt. George L. Browning, Seventh Infantry, will report to the president of the Board for duty as recorder.

All persons interested in magazine guns are invited to appear in person and submit samples, under such rules as may be adopted by the Board. The arms submitted must be caliber .45, and use the United States service cartridge.

Any further information required by those interested may be obtained of the commanding officer National Armory, Springfield, Mass.

The Chief of Ordnance will supply such information and offer such facilities to the Board in the trials and experiments undertaken as may be necessary to the performance of the duty assigned it.

By command of General SHERMAN.

R. C. DRUM.
Adjutant-General.

[Special Orders No. 98.—Extract.]

HEADQUARTERS OF THE ARMY,
ADJUTANT-GENERAL'S OFFICE,
Washington, April 29, 1881.

* * * * * * *

2. By direction of the Secretary of War, Col. R. I. Dodge, aide-de-camp (lieutenant-colonel Twenty-third Infantry), is, at his own request, relieved from duty as member of the Board of Officers appointed to assemble in New York City on the 5th day of July, 1881, by General Orders No. 31, March 21, 1881, from this office, and Col. John R. Brooke, Third Infantry, is detailed in his stead.

* * * * * * *

By command of General SHERMAN.

R. C. DRUM,
Adjutant-General.

Official:

H. C. CORBIN,
Assistant Adjutant-General.

ARMY BUILDING, NEW YORK CITY,
July 5, 1881.

The Board met at 10 a. m.

Present: Colonel Brooke, Captain Benteen, Captain Shorkley, and Captain Greer.

Absent, Captain Litchfield and Captain Browning, the recorder.

An order relieving Captain Browning was read, as follows:

[Special Orders No. 144.—Extract.]

HEADQUARTERS OF THE ARMY,
ADJUTANT-GENERAL'S OFFICE,
Washington, June 25, 1881.

* * * * * * *

6. By direction of the Secretary of War, Capt. George L. Browning, Seventh Infantry, is relieved from duty as recorder of the Board of Offi-

cers appointed by General Orders No. 31, March 21, 1881, from this office.

* * * * * * *

By command of General SHERMAN.

R. C. DRUM,
Adjutant-General.

Official:

C. MCKEEVER,
Assistant Adjutant-General.

The Board then adjourned to meet at 11 a. m. the following day.

ARMY BUILDING,
New York City, July 6, 1881.

The Board met, pursuant to adjournment.

Present: Colonel Brooke, Captain Benteen, Captain Shorkley, Captain Litchfield, and Captain Greer. In the absence of a recorder, Captain Greer acted in that capacity.

Captain Litchfield made an explanation of his absence from the previous meeting.

The room not being ready, the Board adjourned until 11 a. m., July 7.

NEW YORK CITY, *July* 7, 1881.

The Board met, pursuant to adjournment.

Present: Colonel Brooke, Captain Benteen, Captain Shorkley, Captain Litchfield, and Captain Greer, acting recorder.

The following telegram was read:

ADJUTANT-GENERAL'S OFFICE,
Washington, July 5, 1881.

The General of the Army desires you to direct Lieut. Selden A. Day, Fifth Artillery, to repair without delay to New York City and report to Colonel Brooke, Third Infantry, president of Magazine Gun Board, as recorder thereof.

(Signed) R. C. DRUM,
Adjutant-General.

COMMANDING OFFICER, MCPHERSON BARRACKS,
Atlanta, Ga.

The Board passed a resolution to the effect that it will receive all magazine small-arms presented for its consideration, and will require the party presenting each gun to explain it fully, and then to leave it in the hands of the Board for such tests as it may determine upon, at such place as it may select.

There being no further business before it, the Board adjourned until July 8.

NEW YORK CITY, *July* 8, 1881.

The Board met, pursuant to adjournment.

Present: Colonel Brooke, Captain Benteen, Captain Litchfield, Captain Greer, and Captain Shorkley.

Absent: The recorder, First Lieut. S. A. Day, not having arrived from his post.

After a lengthy discussion as to method of procedure, place of sitting, and subjects of similar nature, the Board directed the following letter to be addressed to the Adjutant-General, United States Army:

OFFICE OF BOARD ON MAGAZINE GUNS,
ARMY BUILDING,
New York City, July 8, 1881.

SIR: I am directed by the Board on Magazine Guns to write you, requesting that a supply of 50 or 100 copies, General Orders No. 31, C. S., Headquarters of the Army, convening the Board, may be sent it for distribution to applicants for information in regard to its duties.

Very respectfully, your obedient servant,

JOHN E. GREER,
Captain of Ordnance, Acting Recorder.

The ADJUTANT-GENERAL, UNITED STATES ARMY,
Washington, D. C.

The following letter was also sent:

OFFICE OF BOARD ON MAGAZINE GUNS,
ARMY BUILDING,
New York City, July 8, 1881.

SIR: It appears to the Board, organized by General Orders No. 31, C. S., Headquarters of the Army, that it would be advisable to change the place of sitting of the Board to the National Armory, Springfield, Mass.

The mode of procedure which is thought to be most desirable is to examine each gun presented thoroughly, completing the final tests, and enabling the party presenting the arm to shorten the time of his attendance before the Board.

This would seem to be the course indicated as the best by the proceedings of the Boards which met in September, 1872 (General Terry, president), and that of 1878 (Colonel Benton, president). After completing these tests the Board could return to this city and make up its report.

Very respectfully, your obedient servant,

JOHN R. BROOKE,
Colonel Third Infantry.

The ADJUTANT-GENERAL, UNITED STATES ARMY,
Washington, D. C.

The Board adopted the following rules and tests for the trial of all guns submitted under the order:

Generally these rules will govern the testing of all magazine guns submitted to the Board. It may occur that certain of these tests will be modified, or that others may be substituted for them; the object being to find an arm which will meet the requirements of the Army.

The piece to be first fired ten rounds by the exhibitor, as a test of safety; the same firing to be also a test of rapidity by one familiar with the arm. The time to be noted in the record.

The firing to be then continued, according to the rules annexed, by an employé or person designated by the Board.

The service cartridge to be used in all cases.

No persons will be admitted to the firing-ground but the agents or exhibitors of the gun immediately under trial, and such other persons as may be specially invited by the Board.

The handling of guns by their representatives at any time after the preliminary test for safety is forbidden.

Any arm which has been submitted to the Board and entered upon the record shall remain in the hands of the Board for such time as may be necessary to make drawings explanatory of its mechanism.

If a gun become disabled or unserviceable, all further tests will be discontinued, and the proprietor informed of the fact. If the gun be altered and resubmitted to the Board, it will be treated as a new gun.

REGULAR TESTS.

Safety test: To be fired ten rounds by the exhibitor, or with a lanyard.

I.—RAPIDITY WITH ACCURACY.

The number of shots which, fired in two minutes from the gun—both as a magazine gun and as a single shooter—strike a target 6 feet by 2 feet at a distance of 100 feet. Any cartridges missing fire in this or other tests to be tried with a prick punch, or opened to ascertain the cause of failure. The test to be begun with the chamber or magazine filled, other cartridges to be disposed at will on a table.

II.—RAPIDITY AT WILL.

The number of shots which can be fired in one minute, irrespective of aim, under the same circumstances as in test I.

III.—ENDURANCE.

Each gun to be fired 500 continuous rounds without cleaning, using the magazine. The state of the breech mechanism to be examined at the end of every 50 rounds.

IV.—DEFECTIVE CARTRIDGES.

Each gun to be fired once with each of the following defective cartridges: 1. Cross-filed on head to nearly the thickness of the metal. 2. Cut at intervals around the rim. 3. With a longitudinal cut the whole length of the cartridge, from the rim up. A fresh piece of white paper, marked with the number of the gun, being laid over the breech to observe the escape of gas, if any occur.

V.—DUST.

The piece to be exposed in the box prepared for that purpose to a blast of fine sand-dust for 2 minutes; to be removed, fired 20 rounds, replaced for 2 minutes, removed and fired 20 rounds more.

VI.—RUST.

The breech mechanism and receiver to be cleansed of grease, and the chamber of the barrel greased and plugged, the butt of the gun to be inserted to the height of the chamber in a solution of sal-ammoniac for 10 minutes, exposed for two days to the open air standing in a rack, and then fired 20 rounds.

VII.—EXCESSIVE CHARGES.

To be fired once with 85 grains of powder and one ball of 405 grains of lead; once with 90 grains and one ball, and once with 90 grains and two balls. The piece to be closely examined after each discharge.

Any gun failing in any of the foregoing tests will not be submitted to further tests.

*SUPPLEMENTARY TESTS.**

1st. To be fired with two defective cartridges, Nos. 1 and 2, and then to be dusted five minutes, the mechanism being in the mouth of the blow-pipe, and closed, the hammer being at half-cock; then to be fired 6 shots, the last two defective Nos. 1 and 2; then without cleaning to be dusted with the breech open and fired 4 shots. The piece to be freed from dust only by pounding or wiping with the bare hand.

2d. To be fired 5 rounds with the service cartridge; then without cleaning to be fired 5 rounds with 120 grains powder and a ball weighing 1,200 grains; the gun to stand 24 hours after firing without cleaning, and then to be thoroughly examined.

3d. Facility of manipulation by members of the Board.

4th. Liability to accidental explosions of cartridges in the magazine.

Additional tests may be made by the Board to clear up doubts raised by previous trials.

To determine the comparative rapidity of fire and facility of manipulation, as contemplated by the third supplementary test, each gun to be fired 20 shots by three men to be selected by the Board, loading from the cartridge-box and firing with aim at a target of suitable size 100 yards distant. The average of the three trials to be the recorded time of firing 20 rounds. The magazine to be loaded from the cartridge-box before the start, the remainder of the cartridges to be fired away first, using the gun as a single shooter, and the magazine to be emptied last.

Under the fourth supplementary test, in addition to the test already made of giving a jolting motion to a column of cartridges in a vertical tube with the spiral magazine-spring, a column of six cartridges to be jolted in a tube without the spring, and if there be no explosion, then the lowest bullet in the column to be replaced by a pointed steel plug, first using the spring below the plug, and, in event of it not producing explosion, to be tried without the spring. Also, if there is no explosion resulting from the jolting tests, the tube containing the column of cartridges heavily weighted at the lower end to insure its vertical position, and having the spring at the bottom of the tube, to be dropped from a height of 20 feet upon a pavement; and, if there is no explosion, to be dropped as before without the spring in the tube. Afterward, a pointed steel plug to replace the lowest bullet in the column, and to be dropped with the spring in the tube; then, if there is no explosion, the dropping to be finally tried with the spring removed. These tests to be applied equally to the Frankford and exterior-primed cartridges.

The comparative convenience of carrying the different guns and executing the manual of arms to be considered and tested.

The Board then adjourned to meet on July 11.

NEW YORK CITY, *July* 11, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

After some discussion, the set of rules referred to in the minutes for the preceding session of the Board was ordered printed, and, in accordance with authority from the Chief of Ordnance, a copy was forwarded to the commanding officer National Armory, Springfield, Mass., for that purpose.

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* To be applied only to such arms as have passed through the regular tests in a manner satisfactory to the Board.

Philip Boch submitted to the Board a gun of his invention, with detachable magazine holding twenty cartridges. The piece offered was, however, of .40-caliber, and was withdrawn with a view of submitting one of the proper caliber at some future day.

Other gentlemen representing several magazine guns came before the Board asking information, and stating that they expect to present guns for examination.

The Board adjourned at 2 p. m. to meet at 11 a. m. the 12th instant.

NEW YORK CITY, *July* 12, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

There being no business before it, the Board adjourned to meet at 11 a. m. the 13th instant.

NEW YORK CITY, *July* 13, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

Two communications were sent to the Adjutant-General of the Army, one requesting authority to adjourn to the National Armory, at Springfield, Mass., for the purpose of testing guns, the other requesting authority to employ a clerk for the Board.

There being no further business before it, the Board adjourned until the 14th instant.

NEW YORK CITY, *July* 14, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The following order from the War Department was received and read:

[Special Orders No. 157.—Extract.]

HEADQUARTERS OF THE ARMY,
ADJUTANT-GENERAL'S OFFICE,
Washington, D. C., July 12, 1881.

* * * * * * *

7. By direction of the Secretary of War the board of officers appointed to assemble in New York City, by General Orders No. 31, March 21, 1881, from this office, to examine and consider magazine guns, and recommend such as in its judgment are suitable for the military service, is authorized to adjourn its sittings to the National Armory, Springfield, Mass., for the purpose of testing guns, &c.

* * * * * * *

By command of General Sherman.

R. C. DRUM,
Adjutant-General.

Official.

H. C. CORBIN,
Assistant Adjutant-General.

The Board therefore resolved that when it should adjourn to day it would be to meet at the National Armory, Springfield, Mass., on the 2d day of August, 1881. It was further resolved that in the mean time notice should be sent to the Army and Navy Journal, with a copy of the rules governing the tests to which guns are to be subjected.

NATIONAL ARMORY,
Springfield, Mass., August 2, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

By direction of the Board, several communications were answered, and various details concerning the time of holding sessions, &c., were discussed.

A letter from the Adjutant-General's Office was received, authorizing the employment of a clerk.

There being no further business before it, the Board adjourned to meet at 11 o'clock the following day.

SPRINGFIELD, MASS., *August* 3, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board resolved that the recorder be instructed to communicate with exhibitors and inventors who have expressed their wish to present guns for examination, stating that the Board is ready and waiting to receive their guns, and asking when they will be presented.

The following letter was accordingly sent to W. G. Burton, John L. Suess, William Trabue, and B. C. W. Alexander:

OFFICE OF THE BOARD ON MAGAZINE GUNS,
NATIONAL ARMORY,
Springfield, Mass., August 3, 1881.

DEAR SIR: By direction of the Board, I am instructed to inform all exhibitors of magazine guns who have expressed their wish to present arms for examination, that the Board is now ready and waiting to receive them, and to ask when they will be presented.

Very respectfully, your obedient servant,

S. A. DAY,
First Lieutenant, Fifth Artillery, Recorder.

A telegram was received and read from J. N. Reece, asking information as to the latest date when the Board will receive guns. A letter was read from C. W. Alexander, asking particulars as to tests, &c., with a view to presenting a gun. A copy of the rules was sent to him.

The Board then adjourned to meet on the following day at the usual hour.

SPRINGFIELD, MASS., *August* 4, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

There being no business before the Board, it adjourned to meet the following day.

SPRINGFIELD, MASS., *August* 5, 1881.

The Board met pursuant to adjournment.

Present, all the member and the recorder.

There being no business before it, the Board adjourned to meet at 11 a. m. on Tuesday, August 9.

SPRINGFIELD, MASS., *August* 9, 1881.

The Board met pursuant to adjournment.

Present, Colonel Brooke, Captain Shorkley, Captain Litchfield, Captain Greer, and the recorder.

Absent, Captain Benteen, by permission of the Board.

Mr. J. F. Whipple, representing Messrs. E. Remington & Sons, appeared before the Board, and presented the Remington-Keene magazine gun for examination, taking apart and assembling two models—carbine and rifle—numbered 1 and 2, differing only in one having a fly, which secured it at half-cock on loading; the other (rifle), without.

The Board then adjourned to meet at 10.30 a. m. the following day.

SPRINGFIELD, MASS., *August* 10, 1881.

The Board met pursuant to adjournment.

Present, Colonel Brooke, Captain Shorkley, Captain Litchfield, Captain Greer, and the recorder.

Absent, Captain Benteen, by permission of the Board.

The Remington-Keene gun was taken apart and assembled by an expert from the factory of E. Remington & Sons, the time for which was—

Assembling (carbine), 3′ 30.″

The Board adjourned at 4 p. m. to meet at 10.30 a. m. the following day.

SPRINGFIELD, MASS., *August* 11, 1881.

The Board met pursuant to adjournment.

Present, Colonel Brooke, Captain Shorkley, Captain Litchfield, Captain Greer, and the recorder.

Absent, Captain Benteen (sick).

The members present continued the examination and study of the mechanism of the Remington-Keene guns, and, at 4 p. m., adjourned, to meet at 10.30 a. m. the following day.

SPRINGFIELD, MASS., *August* 12, 1881.

The Board met pursuant to adjournment.

Present, Colonel Brooke, Captain Shorkley, Captain Litchfield, Captain Greer, and the recorder.

Absent, Captain Benteen (sick).

After further examination of the Remington-Keene system, the Board adjourned, to meet at 10.30 a. m. the following day.

SPRINGFIELD, MASS., *August* 13, 1881.

The Board met pursuant to adjournment.

Present, Colonel Brooke, Captain Shorkley, Captain Litchfield, Captain Greer, and the recorder.

Absent, Captain Benteen (sick).

After arranging a programme for testing the guns for safety, the Board adjourned, to meet Monday, the 15th instant, at 10.30 a. m.

SPRINGFIELD, MASS., *August* 15, 1881.

The Board met pursuant to adjournment.

Present, Colonel Brooke, Captain Shorkley, Captain Litchfield, Captain Greer, and the recorder.

Absent, Captain Benteen (sick).

The Board proceeded to the examination of the Boch gun, presented by Mr. Philip Boch. The gun was taken apart and assembled by the exhibitor, and a general study of its mechanism was made by the members of the Board.

The detachable magazine becoming unserviceable, Mr. Boch requested time to repair it before further exhibition of his system.

During the session of the Board, Captain Benteen appeared, taking his seat.

After further consideration of the Boch gun, the Board adjourned, to meet at 10 a. m. the following day.

SPRINGFIELD, MASS., *August* 16, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board proceeded to the trial of the Remington-Keene guns Nos. 1 and 2, completing the safety tests, the tests for rapidity with accuracy and for rapidity at will, with the results stated in the synopsis. The Boch gun was also briefly considered.

The Board then adjourned, to continue the tests on the following day.

SPRINGFIELD, MASS., *August* 17, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board proceeded to the trial of the Hotchkiss guns Nos. 4 and 5, brought before it by Mr. George E. Albee for the Winchester Arms Company, with the results stated in the synopsis.

At 2 p. m. the Board took up the Remington-Keene gun No. 2, for the test of endurance, with the results given in the synopsis, and at 5.30 p. m. adjourned, to meet at 10 a. m. the following day.

SPRINGFIELD, MASS., *August* 18, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The trial of the Remington-Keene gun No. 2 was continued through the "dusting test," with the result given in the synopsis.

At 2 p. m. the Board took up the further consideration of the Hotchkiss gun No. 4, giving it the III (endurance), IV (defective cartridges), and V (dust) tests, with the results stated in the synopsis. After this the Board adjourned, to meet at 10 a. m. the following day.

SPRINGFIELD, MASS., *August* 19, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The weather being inclement and unsuitable for testing guns, the Board adjourned, to meet at 10 a. m. the following day.

SPRINGFIELD, MASS., *August* 20, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board proceeded with the trial of the Hotchkiss No. 5, also Remington-Keene No. 1, subjecting them to the endurance and dusting tests, with results as stated in the synopsis.

At 5 p. m. the Board adjourned, to meet on Monday, 22d instant, at 10 a. m.

SPRINGFIELD, MASS., *August* 22, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board proceeded with rust test for guns Nos. 1, 2, 4, and 5, subjecting them to the preliminary stage, after which the Board adjourned to meet Wednesday, 24th instant, at 10.30 a. m.

SPRINGFIELD, MASS., *August* 24, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board proceeded with the rust test of guns Nos. 1, 2, 4, and 5, with the results stated in the synopsis.

There being no further business before the Board, and no prospect of any at an early date, it resolved that when it adjourns to-day it be to meet on the 21st day of September next, or at an earlier date, if called together by the president.

SPRINGFIELD, MASS., *September* 21, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

There being no business before it, and in view of the obsequies of the late President, to take place on the 26th instant, the Board adjourned, to meet the 27th instant at 10 a. m.

SPRINGFIELD, MASS., *September* 27, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The representatives of the guns which had come in not being present, and there being no business before it, the Board adjourned, to meet tomorrow at 10 a. m.

SPRINGFIELD, MASS., *September* 28, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

Mr. R. S. Chaffee came before the Board with the Chaffee-Reece gun No. 6, explained its working, and the Board proceeded with the tests, with results as stated in the synopsis, after which it adjourned, to meet at 10 a. m. the following day.

SPRINGFIELD, MASS., *September* 29, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board continued the tests with the Chaffee-Reece gun No. 6, with results as stated in the synopsis.

The Board then adjourned, to meet October 1st proximo, at 10 a. m

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SPRINGFIELD, MASS., *October* 1, 1881.

The Board met pursuant to adjournment.

Present, Colonel Brooke, Captain Shorkley, Captain Litchfield, Captain Greer, and the recorder.

Absent, Captain Benteen, by permission of the Board.

The Board continued the tests with the Chaffee-Reece gun No. 6, with the results stated in the synopsis, after which it adjourned, to meet on Monday, October 10, at 10 a. m.

SPRINGFIELD, MASS., *October* 10, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board proceeded to the trial of the Boch gun No. 7, with result as stated in the synopsis.

The Board then adjourned, to meet at 10 a. m. the following day.

SPRINGFIELD, MASS., *October* 11, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board proceeded to the trial of the Remington-Keene gun No. 8, with results as stated in the synopsis.

The Board then adjourned, to meet at 10 a. m. the following day.

SPRINGFIELD, MASS., *October* 12, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board continued the tests with the Remington-Keene gun No. 8, with results as stated in the synopsis, after which it adjourned, to meet on Friday, the 14th instant, at 10 a. m.

SPRINGFIELD, MASS., *October* 14, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The following communication from the War Department was received and read:

WAR DEPARTMENT,
ADJUTANT-GENERAL'S OFFICE,
Washington, October 13, 1881.

SIR: Upon the recommendation of the Chief of Ordnance, the Secretary of War directs that the Board on Magazine Guns examine into and report upon the advisability of using the rifle cartridge in the carbine, and dispensing altogether with the carbine cartridge.

You will please acknowledge receipt of this communication.

I am, sir, very respectfully, your obedient servant,

CHAUNCEY McKEEVER,
Acting Adjutant-General.

Col. JNO. R. BROOKE,
Third Infantry, President Board on Magazine Guns, Springfield, Mass.

The Board continued the tests with the Remington-Keene gun No. 8, with results as stated in the synopsis; after which it adjourned, to meet on Monday, the 17th instant, at 10 a. m.

SPRINGFIELD, MASS., *October* 17, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board discussed plans for testing the rifle and carbine cartridges in the carbine as required by the letter of October 13th; and

"*Resolved*, That the Board experiment with the rifle and carbine cartridges at the various ranges, fired from the shoulder and recoil rest, with the carbine, compare the results as to accuracy and the effect of the recoil on the shooter, with a view to determining the desirability of using the rifle cartridge in the carbine and dispensing with the carbine cartridge."

The Board then adjourned, to meet at 10 a. m. the following day.

SPRINGFIELD, MASS., *October* 18, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

Messrs. Remington, Elliott, and Whipple came before the Board and exhibited two guns, one in model; but none were presented for test.

The Board then adjourned, to meet at 10 a. m. the following day.

SPRINGFIELD, MASS., *October* 19, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

Mr. Albee, representing the Winchester Repeating Arms Company, submitted a new modification of the Hotchkiss gun No. 9, which the Board proceeded to test, with results stated in the synopsis.

Mr. Borchardt, representing the Lee Arms Company, presented the Lee gun No. 10, for examination and test; which was commenced, with the results as stated in the synopsis.

The Board then adjourned, to meet at 10 a. m. the following day.

SPRINGFIELD, MASS., *October* 20, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board proceeded with the tests with the Hotchkiss No. 9 and Lee No. 10 guns, with results as stated in the synopsis.

The Board then adjourned, to meet at 10 a. m. the following day.

SPRINGFIELD, MASS., *October* 21, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board proceeded with the test of the Lee gun No. 11, with the result as stated in the synopsis; after which it adjourned, to meet at 10 a. m. the following day.

SPRINGFIELD, MASS., *October* 22, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board proceeded with the tests of the Hotchkiss No. 9 and Lee Nos. 10 and 11 guns, with results as stated in the synopsis; after which it adjourned, to meet on Monday, 24th instant, at 2 p. m.

SPRINGFIELD, MASS., *October* 24, 1881.

The Board met pursuant to adjournment.

Present, Colonel Brooke, Captain Benteen, Captain Shorkley, Captain Greer, and the recorder.

Absent, Captain Litchfield, by permission of the Board.

The Board proceeded with the testing of Lee guns Nos. 10 and 11, with results as stated in the synopsis; after which it adjourned, to meet at 10 a. m. the following day.

SPRINGFIELD, MASS., *October* 25, 1881.

The Board met pursuant to adjournment.

Present, Colonel Brooke, Captain Benteen, Captain Shorkley, Captain Greer, and the recorder.

Absent, Captain Litchfield, by permission of the Board.

A communication asking certain information in regard to the cartridges used in the experiments of the Board was addressed to the Adjutant-General.

The Board then adjourned, to meet at 10 a. m. the following day.

SPRINGFIELD, MASS., *October* 26, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board discussed methods and plans for carrying out the requirements of the letter from the Adjutant-General, relating to the advisability of using the rifle cartridge in the carbine and dispensing with the carbine cartridge, and adopted the following rules to govern in the experiments:

Resolved, That the Board will conduct its experiments by such means and methods as it may deem proper and advisable, generally as follows:

The carbines used in the experiments shall be those that have been rigidly inspected and proved at the National Armory.

TESTS.

With three or more service carbines—

1st. Two or more men firing 3 scores of 20 shots each, cleaning the barrel after each score of 20 shots and after each shot in one score of 20 shots, at each range.

2d. That the firing be made with both the carbine and rifle cartridges, and at ranges of 200, 300, 500, 600, 800, and 1,000 yards.

3d. The firing will be from at least three positions, viz, muzzle-rest, standing, and "any position" lying.

4th. That members of the Board fire the carbine with the rifle cartridge to determine whether there be excessive recoil, in addition to other usual tests for determining the comparative amount of recoil in fire-arms.

5th. That the firing from the fixed or muzzle-rest be from a muzzle-block or support giving such degree of elasticity as may be found to give most uniform results.

The Board then proceeded to the preliminary experiments with rifle and carbine cartridges in carbines, after which it adjourned to meet at 10 a. m. the following day.

SPRINGFIELD, MASS., *October* 27, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board proceeded with the experiments with rifle and carbine cartridges in the carbine, with results as stated in the special report; after which it adjourned to meet at 10 a. m. the following day.

SPRINGFIELD, MASS., *October* 28, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board continued the experiments with the rifle and carbine cartridges, with results as stated in the special report, after which it adjourned to meet on Monday 31st instant at 10 a. m.

SPRINGFIELD, MASS., *October* 31, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The weather being too inclement for conducting experiments out of doors, the Board adjourned to meet at 10 a. m. the following day.

SPRINGFIELD, MASS., *November* 1, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board continued the experiments with the rifle and carbine cartridges, with results as stated in the special report, after which it adjourned to meet at 10 a. m. the following day.

SPRINGFIELD, MASS., *November* 2, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board proceeded with the experiments with the carbine and rifle cartridges, with results as stated in the special report, after which it adjourned to meet at 10 a. m. the following day.

SPRINGFIELD, MASS., *November* 3, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The letter to the Adjutant-General, of October 25th, was received back, with the following indorsements:

[Second indorsement.]

ORDNANCE OFFICE, WAR DEPARTMENT,
Washington, October 29, 1881.

Respectfully returned to the Secretary of War, through the Adjutant-General, U. S. A.

My recommendation was intended to include *both bullets*, with 70 grains powder charge.

S. V. BENÉT,
Brigadier-General, Chief of Ordnance.

[Third indorsement.]

ADJUTANT-GENERAL'S OFFICE,
Washington, November 1, 1881.

Respectfully returned to the president of the Board on Magazine Guns, inviting attention to the indorsement of the Chief of Ordnance.

R. C. DRUM,
Adjutant-General.

The Board proceeded with the testing of the rifle and carbine cartridges, with results as stated in special report, after which it adjourned to meet at 10 a. m. the following day.

SPRINGFIELD, MASS., *November* 4, 1881.

The Board met pursuant to adjournment.

Present, Captain Benteen, Captain Shorkley, Captain Litchfield, Captain Greer, and the recorder.

Absent: Colonel Brooke (sick).

The Board continued the experiments with the rifle and carbine cartridges, with results as stated in the special report.

The Board then adjourned to meet on Monday, the 7th instant, at 9 a. m.

SPRINGFIELD, MASS., *November* 7, 1881.

The Board met pursuant to adjournment.

Present, Colonel Brooke, Captain Benteen, Captain Shorkley, Captain Greer, and the recorder.

Absent, Captain Litchfield, excused by the Board.

The Board continued the experiments with the rifle and carbine cartridges, with results as stated in the special report, after which it adjourned to meet at 10 a. m. the following day.

SPRINGFIELD, MASS., *November* 8, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The weather being too inclement for conducting experiments out of doors, the Board proceeded with the comparison of data already obtained and the discussion of future experiments and other matters, after which it adjourned to meet at 9 a. m. the following day.

SPRINGFIELD, MASS., *November* 9, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board proceeded with the experiments, testing the recoil of the various cartridges in the carbine, after which it adjourned to meet at 9 a. m. the following day.

SPRINGFIELD, MASS., *November* 10, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board proceeded with the experiments, firing the carbine at the 500-yards range, after which it adjourned to meet at 9 a. m. the following day.

SPRINGFIELD, MASS., *November* 11, 1881.

The Board met pursuant to adjournment.

Present, Colonel Brooke, Captain Benteen, Captain Shorkley, Captain Greer, and the recorder.

Absent, Captain Litchfield, with consent of the Board.

The Board continued the experiments, firing the carbine at the 600-yards range, after which it adjourned to meet on Monday, 14th instant, at 10 o'clock a. m.

SPRINGFIELD, MASS., *November* 14, 1881.

The Board met pursuant to adjournment.

Present, Colonel Brooke, Captain Benteen, Captain Shorkley, Captain Greer, and the recorder.

Absent, Captain Litchfield, with consent of the Board.

The Board continued the experiments with the rifle and carbine cartridges, with results as given in special report.

In the afternoon Mr. William Trabue came before the Board presenting the Trabue gun, showing its mechanism and explaining its working; after which the Board adjourned to meet at 9 a. m. the following day.

SPRINGFIELD, MASS., *November* 15, 1881.

The Board met pursuant to adjournment.

Present, Colonel Brooke, Captain Benteen, Captain Shorkley, Captain Greer, and the recorder.

Absent, Captain Litchfield, with consent of the Board.

The Board proceeded with the trial of the Trabue gun No. 12, with results as given in the synopsis, after which it adjourned to meet at 9 a. m. the following day.

SPRINGFIELD, MASS., *November* 16, 1881.

The Board met pursuant to adjournment.

Present, Colonel Brooke, Captain Benteen, Captain Shorkley, Captain Greer, and the recorder.

Absent, Captain Litchfield, with consent of the Board.

The Board continued the experiments with the carbine and rifle cartridges, with the results given in the special report, after which it adjourned to meet at 9 a. m. the following day.

SPRINGFIELD, MASS., *November* 17, 1881.

The Board met pursuant to adjournment.

Present, Colonel Brooke, Captain Benteen, Captain Shorkley, Captain Greer, and the recorder.

Absent, Captain Litchfield, with consent of the Board.

The Board continued the experiments with the carbine and rifle cartridges, with results given in the special report, after which it adjourned to meet at 9 a. m. the following day.

SPRINGFIELD, MASS., *November* 18, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

Mr. Philip Boch came before the Board, submitting a new gun of his invention for trial, with which the Board proceeded, with results as stated in the synopsis.

Lieut. A. H. Russell also came before the Board, exhibiting a gun of his invention, explaining its mechanism and working and stating that he expected to have it ready for trial on the 28th instant.

The Board in the afternoon continued the experiments with carbine cartridges, firing at 1,000 yards range, with results as stated in the special report, after which it adjourned to meet at 10 a. m. the following day.

SPRINGFIELD, MASS., *November* 19, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The weather being too inclement for conducting experiments out of doors, and there being no other business before it, the Board adjourned to meet Monday the 21st instant, at 9 o'clock a. m.

SPRINGFIELD, MASS., *November* 21, 1881.

The Board met pursuant to adjournment.

Present, all the members and the Recorder.

The Board continued the experiments with the carbine and rifle cartridges, with the results as stated in the special report, after which it adjourned to meet at 9 a. m. the following day.

SPRINGFIELD, MASS., *November* 22, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board continued the experiments with the carbine and rifle cartridges, with results as stated in the special report, after which it adjourned to meet at 9 a. m. the following day.

SPRINGFIELD, MASS., *November* 23, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board having completed the experiments with the carbine and rifle cartridges, adopted the following resolution:

Resolved, That the Board now adjourn its sessions to New York City, to meet at the Army Building, corner of Houston and Greene streets, on Tuesday, the 6th day of December, at 10 o'clock a. m.

In accordance with which a letter was addressed to the Chief of Ordnance requesting that the necessary apparatus, ammunition, &c., for testing guns be sent to New York, and that the commanding officer of the New York Arsenal be directed to furnish facilities for prosecution of the work.

A letter was also sent to the depot quartermaster at New York City, notifying him of the action of the Board and requesting that suitable rooms be furnished and in readiness for its use by the date of meeting.

NEW YORK CITY, *December* 6, 1881—10 o'clock a. m.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

Communications from the Chief of Ordnance and the commanding officer New York Arsenal, referring to facilities for work of the Board, &c., were received.

Lieutenant Russell came before the Board, presenting a gun of his invention, reading and submitting the statement marked A.

The Board then adjourned to meet to-morrow at 10 a. m.

NEW YORK CITY, *December* 7, 1881—10 o'clock a. m.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The weather being too inclement for outdoor work, the Board adjourned to meet to-morrow at 10 o'clock a. m.

NEW YORK CITY, *December* 8, 1881—10 o'clock a. m.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board proceeded with the trial of the gun submitted by Lieutenant Russell, with the results as stated in the synopsis.

The Board then adjourned to meet to-morrow at 10 o'clock a. m.

NEW YORK CITY, *December* 9, 1881.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

Mr. Philip Boch came before the Board resubmitting his gun with modifications, which he explained.

Lieutenant Russell again came before the Board and explained the points of failure in gun submitted for trial, stating that it was his intention to harden the receiver and submit it again.

Mr. Sweeney came before the Board submitting the Marlin gun for examination and trial.

The Board then proceeded with the trial of the Boch gun No. 15, with results as stated in the synopsis.

After which the Board adjourned to meet at the Army Building on Monday, the 12th instant, at 10 o'clock a. m.

NEW YORK CITY, *December* 12, 1881—10 o'clock a. m.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board continued the test with the Boch gun No. 15, subjecting it to the rusting bath, after which the Marlin gun No. 16 was taken up and tested, with the results as stated in the synopsis.

The Board then adjourned to meet Wednesday, the 14th instant, at 10 a. m.

NEW YORK CITY, *December* 14, 1881.

The Board met pursuant to adjournment.

Present, Colonel Brooke, Captain Benteen, Captain Shorkley, Captain Litchfield, and the recorder.

Absent, Captain Greer (sick).

The Board continued the tests of the Boch gun No. 15, with results as stated in the synopsis.

The following communication from the Adjutant-General of the Army was received and read:

HEADQUARTERS OF THE ARMY,
ADJUTANT-GENERAL'S OFFICE,
Washington, December 12, 1881.

SIR: I am instructed by the General of the Army to say that he desires the Board on Magazine Guns to take into consideration the propriety and feasibility of the adoption of a rifle adapted to all arms of the service, cavalry, artillery, and infantry, and which would supersede the carbine.

Very respectfully, your obedient servant,

R. C. DRUM,
Adjutant-General.

Col. JOHN R. BROOKE,
Third Infantry, President Board on Magazine Guns, New York City.

The Board then adjourned to meet to-morrow at 9.30 a. m.

NEW YORK CITY, *December* 15, 1881—9.30 a. m.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board proceeded with the testing of Lieutenant Russell's gun No. 17, with results as stated in the synopsis (see Appendix B).

The Board then adjourned to meet to-morrow at 10.30 a. m.

NEW YORK CITY, *December* 16, 1881—10.30 o'clock a. m.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board heard Lieutenant Russell, of the Ordnance Corps, in regard to recommending the manufacture of a new bolt system for small-arms, invented by him.

After duly considering the essay and model submitted by Lieutenant Russell, the Board informed him that they were not satisfied that the model was of such a character as to justify such recommendation on their part. The Board think Lieutenant Russell is in no way prohibited from asking this favor of the Secretary of War (see Appendix C).

The Board then adjourned to meet to-morrow, the 17th, at 10.30 a. m.

NEW YORK CITY, *December* 17, 1881—10.30 a. m.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board continued the testing of gun No. 17, putting it in the rusting bath at 11 o'clock a. m.

The Board then adjourned to meet Monday, the 19th day of December, 1881, at 10 o'clock a. m.

NEW YORK CITY, *December* 19, 1881.

The Board met pursuant to adjournment.

Present, all the members.

Absent, the recorder, excused by the Board.

The Board completed the primary test of gun No. 17, with results as stated in the synopsis, after which it adjourned to meet Monday, the 3d day of January, 1882, at 11 a. m.

NEW YORK CITY, *January* 3, 1882—10 o'clock a. m.

The Board met pursuant to adjournment.

Present, all the members.

Absent, Lieut. S. A. Day, recorder, by permission of the Board.

Letter dated December 27, 1881, was received from the Adjutant-General, stating that Col. J. R. Brooke, president of the Board, was directed by the General of the Army to repair to Washington, D. C., for the purpose of discussing certain matters under consideration by the Board.

A letter was received from the depot quartermaster inclosing copy of communication from the Quartermaster-General of the Army, authorizing the employment of a draughtsman for the use of the Board.

Letter and telegram were received from Mr. Sweeny, representing the J. M. Marlin Fire Arms Company, of New Haven, Conn., and from Mr. William Trabue, respectively, stating that the former would appear before the Board on the 4th, and the latter on the 5th, with their magazine guns.

The assignee of Patrick Cullen, deceased, submitted for the inspection of the Board a magazine gun, caliber .44.

After examination of the gun, the gentleman was informed that ample time would be afforded him to prepare one adapted to the service cartridge when the one submitted was withdrawn.

The president of the Board informed it that he had visited Washington, under orders of the General of the Army, and conferred with him and the Chief of Ordnance in regard to the matter referred to in the letter from the Adjutant-General of the Army, of December 27, 1881.

The Board then entered upon an informal discussion as to the propriety and feasibility of adopting a single arm for all arms of the service, in accordance with the instructions of the General of the Army, as contained in his letter of December 12, 1881, after which the Board adjourned to meet at 10.30 a. m. the 4th instant.

NEW YORK CITY, *January* 4, 1882—10.30 a. m.

The Board met pursuant to adjournment.

Present, all the members.

Absent, Lieut. S. A. Day, recorder, by permission of the Board.

Mr. P. Boch appeared before the Board and submitted his magazine gun, which was received and entered on the docket as No. 18.

Mr. J. J. Sweeney also appeared before the Board with the Marlin magazine gun, which he decided not to submit for the present.

It being impracticable to proceed with tests of guns before the Board on account of the extreme cold weather, the Board adjourned to meet at 11 a. m. the 5th instant.

NEW YORK CITY, *January* 5, 1882—11 o'clock a. m.

The Board met pursuant to adjournment.

Present, all the members.

Absent, Lieut. S. A. Day, recorder, by permission of the Board.

Letter was directed to Mr. Charles P. Hill notifying him that his services as clerk were no longer required by the Board.

The extreme cold weather still continuing, preventing tests of guns, the Board adjourned to meet at 11 a. m. the 6th instant.

NEW YORK CITY, *January* 6, 1882.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board continued the matter under consideration on the 3d instant, after which it adjourned to meet on Monday, the 9th instant, at 10 a. m.

NEW YORK CITY, *January* 9, 1882.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board continued the consideration of the matter under discussion at the last meeting, and agreed upon the following report:

"OFFICE OF THE BOARD OF MAGAZINE GUNS,
"ARMY BUILDING,
"*New York City, January* 9, 1882.

"SIR: In reply to your communication of the 12th December ult., requiring the Board on Magazine Guns to take into consideration the propriety of adopting a rifle for all arms of the service, I have the honor to report that the Board is unanimous in the opinion that it is desirable and feasible to adopt a rifle adapted to all arms of the service, and which would supersede the carbine.

"Very respectfully, your obedient servant,
"JNO. R. BROOKE,
"*Colonel Third Infantry, President of Board.*

"The ADJUTANT-GENERAL, U. S. A.,
"*Washington, D. C.*"

After which it adjourned to meet to-morrow at 10 a m.

NEW YORK CITY, *January* 10, 1882—10 o'clock a. m.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board proceeded with the Boch gun No. 18, a modification of his previous gun, with the results as stated in the synopsis, after which it adjourned to meet to-morrow at 10 a. m.

NEW YORK CITY, *January* 11, 1882—10 o'clock a. m.

The Board met pursuant to adjournment.

Present, all the members except Captain Litchfield, excused by the Board, and the recorder.

The weather being too inclement for out-door work, the Board proceeded with the examination of the target records, &c., with a view to making a special report upon the advisability of using the rifle cartridge in the carbine and dispensing altogether with the carbine cartridge, after which it adjourned to meet to-morrow at 10 a. m.

NEW YORK CITY, *January* 12, 1882—10 o'clock a. m.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board proceeded with the testing of the Trabue gun No. 19, with results as stated in the synopsis.

The Board adjourned to meet to-morrow at 10 a. m.

NEW YORK CITY, *January* 13, 1882.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board examined the applications and recommendations of the several applicants for the clerkship of the Board, and decided to employ Mr. Richardson.

After some discussion of the form of the special report on cartridges the Board adjourned to meet Monday, the 16th, at 10 a. m.

NEW YORK CITY, *January* 16, 1882.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board continued the testing of the Trabue gun No. 19, with results as stated in the synopsis.

The Board then took up the Boch gun No. 20, a modification of No. 18, with results as stated in the synopsis.

A communication was received from the Adjutant-General relating to the recommendation of a rifle suitable for all arms of the service, &c., herewith appended; also one from Lieutenant Russell, of the Ordnance Department, relative to the testing of his gun No. 14, herewith appended.

The Board adjourned to meet to-morrow at 10 a. m.

NEW YORK CITY, *January* 17, 1882.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board considered the subject referred to in the communication of the Adjutant-General of January 13, 1882, after which it adjourned to meet to-morrow at 11 a. m.

NEW YORK CITY, *January* 18, 1882—11 o'clock a. m.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board continued the consideration of the subject of a rifle suitable for all arms of the service, and addressed a letter of inquiry to the Adjutant-General in regard to same, after which it adjourned to meet to-morrow at 11 a. m.

NEW YORK CITY, *January* 19, 1882.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board considered the subject of its report on the advisability of using the rifle cartridge in the carbine and dispensing with the carbine cartridge, after which it adjourned to meet to-morrow at 11 a. m.

NEW YORK CITY, *January* 20, 1882.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board, after some discussion, passed the following resolution:

"*Resolved*, That it has been and is now the desire of the Board to encourage, in all ways consistent with an impartial discharge of its duty, exhibitors and inventors to make and present before the Board such magazine guns as may best suit the requirements of the military service, and to secure this end a fair interchange of ideas with suggestions to inventors from members of the Board is desirable; and still further to stimulate inventors, the recorder will furnish them opportunities, upon application, to examine a copy of the record of the Board of any regular tests made of their guns.

The Board then adjourned to meet Monday, the 23d instant, at 11 a. m.

NEW YORK CITY, *January* 23, 1882.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

A letter from the Adjutant-General of the Army, in reply to the letter of the Board of January 18, 1882, was received. Copy appended.

The Board proceeded with an informal discussion of the matter referred to, after which it adjourned to meet to-morrow at 11 a. m.

NEW YORK CITY, *January* 24, 1882.

The Board met pursuant to adjournment.

All the members present, and the recorder.

In accordance with the request of Maj. Anson Mills, Tenth Cavalry, addressed to a member of the Board, a letter was sent to Mr. F. Vetterly, chief manager Industrial Society, Schaffhauser, Switzerland, inviting him to present for examination and report his magazine rifle.

After further discussion of the matter under consideration, the Board adjourned to meet to-morrow at 11 a. m.

NEW YORK CITY, *January* 25, 1882.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board continued the business under consideration yesterday, after which it adjourned to meet to-morrow at 10 a. m.

NEW YORK CITY, *January* 26, 1882.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board continued the business under consideration yesterday, after which it adjourned to meet Monday, the 30th instant, at 11 a. m.

NEW YORK CITY, *January* 30, 1882.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board continued the further consideration of the subject referred to in the letter of the Adjutant-General of January 21, 1882, after which it adjourned to meet to-morrow at 11 a. m.

NEW YORK CITY, *January* 31, 1882.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board continued the business of yesterday, after which it adjourned to meet to-morrow at 11 a. m.

NEW YORK CITY, *February* 1, 1882.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board continued the business of yesterday and other duties connected with the subject of magazine guns, after which it adjourned to meet to morrow at 11 a. m.

NEW YORK CITY, *February* 2, 1882.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board continued the business of yesterday, including comparison of scores and examination of the record of the experiments with cartridges, after which it adjourned to meet Monday, the 6th instant, at 11 a. m.

NEW YORK CITY, *February* 6, 1882.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board received and examined the Trabue gun No. 21, but on account of the depth of snow on the firing grounds the trial of it was postponed until to-morrow, until which time it then adjourned to meet at 11.30 a. m. on Governor's Island.

NEW YORK CITY, *February* 7, 1882.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board proceeded with the testing of the Trabue gun No. 21, with results as stated in the synopsis, after which it adjourned to meet at the Army Building to-morrow at 11 a. m.

NEW YORK CITY, *February* 8, 1882.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board proceeded with the consideration of its report on the advisability of using the rifle cartridge in the carbine and dispensing with the carbine cartridge, after which it adjourned to meet to-morrow at 11 a. m.

NEW YORK CITY, *February* 9, 1882.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board continued the test of the Trabue gun No. 21, with results as stated in the synopsis, after which the Board adjourned till Monday, the 13th instant, to enable the recorder to verify the record of the cartridge tests before final action in making the report.

NEW YORK CITY, *February* 13, 1882.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board continued the Trabue gun No. 21, with results as stated in the synopsis, after which it adjourned to meet to-morrow at 11 a. m.

NEW YORK CITY, *February* 14, 1882.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board continued the consideration of the subject referred to in the letter from the Adjutant-General of the Army, October 13, 1881, and a report agreed upon, after which it adjourned to meet to-morrow at 11 a. m.

NEW YORK CITY, *February* 15, 1882.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board considered the matter of its report on the advisability of recommending a rifle suitable for all arms of the service, after which it adjourned to meet to-morrow at 11 a. m.

NEW YORK CITY, *February* 16, 1882.

Private Charles J. Dean came before the Board, submitting a magazine gun of his invention.

After examination of its mechanism, &c., the Board submitted it to the tests, with results as stated in the synopsis, after which the Board adjourned to meet Monday, the 20th instant, at 11 a. m.

NEW YORK CITY, *February* 20, 1882.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board adjourned to the testing grounds on Governor's Island for the continuation of the test of gun No. 22, but the inventor failing to put in an appearance, the Board considered the matter of the specifications for the new experimental rifle, after which it adjourned to meet to-morrow at 11 a. m.

NEW YORK CITY, *February* 21, 1882.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board further considered the subject of a rifle suitable for all arms of the service, and agreed upon the following report:

Report of the Board on magazine guns, in compliance with letters of Adjutant-General, United States Army, dated December 12, 1881, *and January* 21, 1882.

After giving the matter a careful and exhaustive consideration, and without experimental tests, the Board would recommend for trial a modified Springfield rifle, caliber .45, as follows:

Barrel to be 28 inches long, to be the same size at muzzle as the present service barrel; to be made nearly a straight taper, and to weigh four ounces more than the present service barrel, with both 3 and 6 grooved rifling, and to be chambered for the $2\frac{1}{10}$ shell.

Sight slide to be so arranged, with a screw, as to have a central fastening to prevent, if desired, lateral sliding, for cavalry use; the graduations adjusted to the 28-inch barrel, leaving the rear sight in the same relative position to the breech block as upon present service barrel.

Breech block to have a friction joint to retain it in any desired position when open.

Stock to be full length, in its present general form, the butt plate to have form of the present long-range Springfield rifle, suited to the present service stock, or perhaps better still the pattern known as shotgun butt used on sporting rifles, using large projectiles and powder charges.

Sling to be used as upon the present service rifle; swivels to be bent to conform to the round of the stock to better adapt it for cavalry use.

Lock to have the stroke of the hammer as much shortened as practicable and retain a three-notched tumbler with hammer as low as possible when in safety notch; the half-cock notch to be as low as practicable and still permit opening of the breech block.

In making this recommendation the Board have consideration for facility of manufacture, and the small cost of producing the rifle for trial, and have taken the Springfield system, as it is believed to be near the length of any approved magazine system it may be desirable to use; and the present service rifle may be taken as a standard of excellence in testing the modified rifle.

The Board recommend only what would seem to it needed changes to secure a desirable adaptability of the Springfield rifle for all branches of the military service, and request that the rifle be prepared at the National Armory, and submitted to the Board for examination before being forwarded to the War Department for trial.

Referring to the last clause of the letter from Headquarters of the Army, dated January 21, 1882, the Board would further recommend, for the purpose of comparative tests of the 28-inch and 30-inch barrels in rifles of the same total length over all, the trial of a 30-inch barrel in some of the many Sharps systems understood to be on hand at the

National Armory. A sample of such a rifle was before the Board and is of the following dimensions, &c.:

Length over all	46¼ inches.
Length of barrel	30 inches.
Weight of arm without bayonet	9¼ pounds.
Diameter of barrel at breech end for ⅓ of its length	1¼ inches.
Diameter of barrel at 2 inches in front of last point	1⅒ inches.
Diameter of barrel at 6 inches from last point	1 inch.
Diameter of barrel at 12 inches from breech	⅞ inch.
Diameter of barrel at 24 inches from breech	$\frac{13}{16}$ inch.
Diameter of barrel at muzzle	¾ inch.

The barrel should be chambered for the 2$\frac{4}{10}$ shell, and the muzzle diameter reduced to carry the bayonet at present in use.

The gun-stock should be full length, and suited to the carrying of a ramrod, sling, &c.

The butt plate should be as broad at the heel as practicable, with all angles well rounded, being the same in general form as heretofore recommended for the Springfield system.

This rifle with its 30-inch barrel is only some 2¾ inches longer than the present Hotchkiss carbine issued to cavalry, and is somewhat shorter than the Springfield rifle with the 28-inch barrel.

Captain Greer desires to state concerning his vote on the resolution in regard to the Sharps system, that the Board convened by General Orders No. 58, Adjutant-General's Office, 1872, of which Brig. Gen. Alfred H. Terry was president, after long, careful, and exhaustive tests of the 99 systems presented, among which was the Sharps, recommended for adoption by the United States that known as the Springfield. In addition, the act of June 6, 1872, under which that Board was organized, expressly provides that the system so recommended "*shall be the only one to be used by the Ordnance Department* in the *manufacture of muskets and carbines for the military service.*" For these reasons Captain Greer records his vote in the negative.

The Board would recommend that more than one rifle of each pattern be made by experiments, and that one of each be sent to the Board for its examination before more are made.

JOHN R. BROOKE,
Colonel Third Infantry.
J. W. BENTEEN,
Captain Seventh Cavalry.
GEORGE SHORKLEY,
Captain Fifteenth Infantry.
H. G. LITCHFIELD,
Captain Second Artillery.
JOHN E. GREER,
Captain of Ordnance.
S. A. DAY,
First Lieutenant Fifth Artillery, Recorder.

Several manufacturers of guns having expressed a willingness to submit to the Board models of rifles filling any specified conditions desired, the following letter was directed to be sent to them:

"I am directed to inform you that the Board on Magazine Guns have under consideration the subject of a suitable single or magazine breech-loading rifle for use of both mounted and foot troops.

It is thought that you might be pleased to submit for examination a model of such arm, complying substantially with the following specifications:

Length over all, 45 to 48 inches.

Length of barrel, 26 to 30 inches.

Weight, without bayonet, 9 to 9¼ pounds.

Fore stock to be of full length, suited to carrying rod, bayonet, &c.

Butt-plate, broad at the heel, as in the "shot-gun" form, and without unnecessary curve or sharp angles.

To be chambered for a .45 caliber 2$\frac{1}{10}$-inch cartridge-shell."

After which the Board adjourned to meet Thursday, the 23d instant, at 11 a. m.

NEW YORK CITY, *February* 23, 1882.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board proceeded with the test of the Dean gun, which was re-entered, with the results as stated in the synopsis, after which it adjourned to meet Monday, the 27th instant, at 11 a. m.

NEW YORK CITY, *February* 27, 1882.

The Board met pursuant to adjournment.

Present, Colonel Brooke, Captains Benteen, Shorkley, and Greer, and the recorder.

Absent, Captain Litchfield, on duty.

A communication was received from Maj. Anson Mills, Tenth Cavalry, with tracings and specifications for a magazine gun of his invention and which he proposed to build at the National Armory under certain conditions. As the letter stated that the matter had been submitted to the Chief of Ordnance, it was read and filed for future consideration.

There being no other business before it, the Board then adjourned to meet to-morrow at 11 a. m.

NEW YORK CITY, *February* 28, 1882.

The Board met pursuant to adjournment.

Present, Colonel Brooke, Captains Benteen, Shorkley, and Greer, and the recorder.

Absent, Captain Litchfield, on duty.

A communication was received from the Lee Arms Company and also one from Mr. J. P. Lee, making certain inquiries in regard to submitting a magazine gun complying with certain specifications, and stating a desire to submit also a single-loader with a cartridge-box of peculiar construction; and to which replies were directed to be sent.

The Board having no further business before it, adjourned to meet to-morrow at 11 a. m.

NEW YORK CITY, *March* 1, 1882.

The Board met pursuant to adjournment.

Present, Colonel Brooke, Captains Benteen, Shorkley, and Greer, and the recorder.

Absent, Captain Litchfield, on duty.

In consequence of Captain Shorkley being ordered to proceed to Washington, and there being no business before it, the Board adjourned to meet Monday, 6th instant.

NEW YORK CITY, *March* 6, 1882.

The Board met pursuant to adjournment.

Present, Colonel Brooke, Captains Benteen, Shorkley, and Greer, and the recorder.

Absent, Captain Litchfield, on duty in Washington.

Mr. Spencer came before the Board with the Spencer-Lee magazine gun No. 24, presented by Mr. J. W. Frazier, of New York.

After an exhibition of its mechanism and working, the weather being inclement, the Board decided to test it the first suitable day.

The Board then adjourned to meet to-morrow at 11 a. m.

NEW YORK CITY, *March* 7, 1882.

The Board met pursuant to adjournment.

Present, Colonel Brooke, Captains Benteen, Shorkley, and Greer, and the recorder.

Absent, Captain Litchfield, on duty in Washington.

The Board proceeded with the tests of the Spencer-Lee gun No. 24, with results as stated in the synopsis; after which it adjourned to meet to-morrow at 10.30 a. m.

NEW YORK CITY, *March* 8, 1882.

The Board met pursuant to adjournment.

Present, Colonel Brooke, Captains Benteen, Shorkley, and Greer, and the recorder.

Absent, Captain Litchfield, on duty in Washington.

The Board continued the testing of the Spencer-Lee gun No. 24, with results as stated in the synopsis, after which it adjourned to meet to-morrow at 11 a. m.

NEW YORK CITY, *March* 9, 1882.

The Board met pursuant to adjournment.

Present, Colonel Brooke, Captains Benteen, Shorkley, and Greer, and the recorder.

Absent, Captain Litchfield, on duty in Washington.

Copy of a letter from the Adjutant-General of the Army to the Chief of Ordnance was received and considered by the Board and a reply sent.

The weather being too inclement forout door work the Board adjourned to meet to-morrow at 11 a. m.

NEW YORK CITY, *March* 10, 1882.

Board met pursuant to adjournment.

Present, Colonel Brooke, Captains Benteen, Shorkley, and Greer, and the recorder.

Absent, Captain Litchfield, on duty in Washington.

The Board continued the testing of gun No. 24, with results as stated in the synopsis, after which the Board adjourned to meet Monday, the 13th instant, at 11 a. m.

NEW YORK CITY, *March* 13, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board proceeded to test the Dean gun, No. 25, with results as stated in the synopsis, after which it adjourned to meet to-morrow at 11 a. m.

NEW YORK CITY, *March* 14, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board proceeded with the testing of the Boch gun, No. 26, with results as stated in the synopsis, after which it adjourned to meet to-morrow at 10 a. m.

NEW YORK CITY, *March* 15, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

Mr. Whipple came before the Board representing Messrs. E. Remington & Sons, presenting a new Remington-Keene gun, which was entered upon the docket as gun No. 27.

After examining its mechanism and working, and noting wherein it differed from the previous guns of the same name, the Board proceeded to test according to the rules with the result as stated in the synopsis, after which the Board adjourned to meet to-morrow at 10 a. m.

NEW YORK CITY, *March* 16, 1882.

The Board met pursuant to adjournment.

Present, all the members and the recorder.

The weather being too inclement for outdoor work, the Board proceeded to the examination of the Boch gun, No. 26, as to the alterations made in it since the test was begun.

The Board then considered the subject of setting a day limiting the date at which guns will be received, after which the Board adjourned to meet Monday, the 20th instant, at 11 a. m.

NEW YORK CITY, *March* 20, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The inventor of the Boch gun set down for continuation of the tests to-day, not presenting himself, and no other business being before it, the Board adjourned to meet to-morrow at 10.30 a. m.

NEW YORK CITY, *March* 21, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The weather being too inclement for outdoor work, the Board adjourned to meet to-morrow at 10.30 a. m.

NEW YORK CITY, *March* 22, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board continued the testing of the Boch gun, No. 26, with results as stated in the synopsis, after which it adjourned to meet to-morrow at 10.30 a. m.

NEW YORK CITY, *March* 23, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

A letter from Lieut. A. H. Russell, transmitting a new and larger magazine for his gun, with a set of cartridge-cases, was received and placed on file, and the following reply directed to be sent:

OFFICE OF BOARD ON MAGAZINE GUNS,
ARMY BUILDING,
NEW YORK CITY, *March* 27, 1882.

SIR: The Board on Magazine Guns desires me to say in reply to your communication of the 17th instant, that it does not understand that your magazine accompanying your letter comes within the scope of the inquiry intended by General Order No. 31, Adjutant-General's Office, series 1881.

It is deemed your province to so arrange your magazine as to come under the head of "magazine guns," which is now the subject of inquiry by the Board.

In its present shape, and under the construction placed on your letter, it would seem you desire the Board to apply your magazine to some gun. If this construction be the one you intend, the Board desires to inform you that it does not so interpret the order convening it, and cannot attempt to carry out your desires.

Copies of the papers submitted by you to the Board will be furnished as soon as practicable, if you will designate which you require.

Very respectfully, your obedient servant,

S. A. DAY,
First Lieutenant, Fifth Artillery, Recorder.

Lieut. A. H. RUSSELL,
Ordnance Department, U. S. A., Rock Island Arsenal, Ill.

Mr. J. W. Sweeney was notified that his gun would be tested on Monday, the 27th instant, after which the Board adjourned to meet Monday, the 27th instant at 10.30 a. m.

NEW YORK CITY, *March* 27, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The weather being too inclement for work out of doors, the Board considered certain correspondence, after which it adjourned to meet to-morrow at 10.30 a. m.

NEW YORK CITY, *March* 28, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board proceeded with the test of the Marlin gun, No. 28, with results as stated in the synopsis, after which it adjourned to meet to-morrow at 10.30 a. m.

NEW YORK CITY, *March* 29, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board continued the test of the Marlin gun with results as stated in the synopsis, after which it adjourned to meet to-morrow at 10.30 a. m.

NEW YORK CITY, *March* 30, 1882.

Board met pursuant to adjournment.

Present, Captains Benteen, Litchfield, Shorkley, and Greer, and the recorder.

Absent, Colonel Brooke (sick).

The Board on account of the inclemency of the weather and absence of the president, sick, adjourned to meet Monday, the 3d of April.

NEW YORK CITY, *April* 3, 1882.

Board met pursuant to adjournment.

Present, Captains Benteen, Shorkley, Litchfield, and Greer, and the recorder.

Absent, Colonel Brooke.

The Board continued the tests of the Boch gun, No. 26, and Marlin gun, No. 28, with results as stated in the synopsis, after which it adjourned to meet to-morrow at 10 o'clock a. m.

NEW YORK CITY, *April* 4, 1882.

Board met pursuant to adjournment.

Present, Captains Benteen, Shorkley, Litchfield, and Greer, and the recorder.

Absent, Colonel Brooke.

The Board proceeded with the test of the Remington-Keene gun, No. 29, submitted by Mr. Whipple, with results as stated in the synopsis, after which it adjourned to meet to-morrow at 10.30 a. m.

NEW YORK CITY, *April* 5, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

A letter from Mr. H. Elliot was received and considered, and a reply stating the substantial compliance with his request was directed to be sent; after which, there being no other business before it, the Board adjourned to meet Monday, the 17th instant, at 11 a. m.

NEW YORK CITY, *April* 17, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board proceeded with the tests of the Remington-Keene gun, No. 30, with results as stated in the synopsis, after which the Board adjourned to meet to-morrow at 10.30 a. m.

NEW YORK CITY, *April*, 18, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board continued the tests of gun No. 30, with results as stated in the synopsis, and also considered the subject of fixing a date at which it would cease to receive guns for examination, after which it adjourned to meet the 20th instant at 10.30 a. m.

NEW YORK CITY, *April* 20, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board continued the test of gun No. 30, with results as stated in the synopsis, after which it adjourned to meet to-morrow at 10.30 a. m.

NEW YORK CITY, *April* 21, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board considered the subject of fixing a date at which new models will be received, and the following communication was sent to the Adjutant-General of the Army:

OFFICE OF BOARD ON MAGAZINE GUNS,
ARMY BUILDING,
New York City, April 21, 1882.

SIR: The Board on Magazine Guns would respectfully report that up to the present time it has examined and tested thirty guns. That it has known of about six more still to come, the inventors having signified their intentions to submit them, and it would ask whether, under the circumstances, it is desirable at this time to fix a date limiting the time that new models may be received and examined.

Very respectfully, your obedient servant,

JOHN R. BROOKE,
Colonel Third Infantry, President of Board.

To the ADJUTANT-GENERAL,
United States Army, Washington, D. C.

There being no other business before it, the Board adjourned to meet Monday, the 1st day of May, or sooner, at the call of the president.

NEW YORK CITY, *May* 1, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board considered the advisability of permitting the inventors of the Remington-Keene, gun No. 30, to make a slight modification of the model tested, and which was decided in the affirmative, after which it adjourned to meet to-morrow at 11 a. m.

NEW YORK CITY, *May* 2, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

There being no business before it, the Board adjourned to meet Tuesday, the 9th instant, at 11 a. m.

NEW YORK CITY, *May* 9, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

A communication was received from the Adjutant-General of the Army relative to fixing a date limiting the time for the receipt of new models of guns for examination; also one from Lieutenant Russell, of the Ordnance Corps, withdrawing his gun for modification and repairs.

The Board adjourned to meet Thursday, the 11th instant, at 10 a. m.

NEW YORK CITY, *May* 11, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

There being no business before it, the Board adjourned to meet Monday, the 15th instant, at 11 a. m.

NEW YORK CITY, *May* 15, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The gun expected for trial to-day not having been presented, and there being no other business before it, the Board adjourned to meet to-morrow at 10.30 a. m.

NEW YORK CITY, *May* 16, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The gun expected, not coming in, the Board adjourned to meet to-morrow at 11 a. m.

NEW YORK CITY, *May* 17, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

Mr. Frazier came before the Board, presenting the Spencer-Lee gun for test, with which the Board proceeded, with results as stated in the synopsis, after which it adjourned to meet to-morrow at 10.30 a. m.

NEW YORK CITY, *May* 18, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board continued the test of the Spencer-Lee gun, with results as stated in the synopsis, after which it adjourned to meet at the call of the president.

NEW YORK CITY, *June* 15, 1882.

Board met pursuant to adjournment, at call of the president.

Present, all the members and the recorder.

The Board proceeded with the testing of the Dean gun, No. 32, and Chaffee-Reece gun, No. 33, with results as stated in the synopsis, after which the Board adjourned to meet Monday, the 19th, at 10 a. m.

NEW YORK CITY, *June* 19, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board continued the test of the Chaffee-Reece gun, No. 33, with results as stated in the synopsis. There being no further business before it, the Board then adjourned to meet at the call of the president.

NEW YORK CITY, *June* 27, 1882.

Board met pursuant to adjournment, at the call of the president.

Present, all the members and the recorder.

The Board proceeded with the examination and testing of the Hotchkiss gun, No. 34, with results as stated in the synopsis, after which it adjourned to meet the 30th instant at 10.30 a. m.

NEW YORK CITY, *June* 30, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board continued the testing of the Hotchkiss gun, No. 34, with results as stated in the synopsis.

A letter from Maj. Anson Mills, Tenth Cavalry, was read and considered.

There being no further business before it, the Board adjourned to meet at the call of the president.

NEW YORK CITY, *July* 10, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board proceeded with the testing of the Spencer-Lee gun, No. 35, with results as stated in the synopsis.

Mr. W. G. Burton came before the Board, submitting two models of magazine guns, and asking that a day be set for submitting them to the tests at which he could be present.

Mr. Burton was informed that he would be notified when his guns could be taken up.

The Board then adjourned to meet to-morrow at 10.30 a. m.

NEW YORK CITY, *July* 11, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board proceeded with the testing of the Lee gun, No. 36, with results as stated in the synopsis, after which it adjourned to meet to-morrow at 10.30 a. m.

NEW YORK CITY, *July* 12, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

Mr. A. Sheridan Jones, of Dakota, came before the Board, expressing a desire to submit to it a gun of his invention in a few days.

A communication from the *Société Industrielle Suisse*, in reference to submitting the Veterli magazine gun, was forwarded to the Adjutant-General of the Army for instructions in the case.

The Board then adjourned to meet to-morrow at 10.30 a. m.

NEW YORK CITY, *July* 13, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board proceeded with the testing of the Spencer-Lee gun, No. 35, with results as stated in the synopsis.

A resolution was passed directing the recorder to be present at the office of the Board on the 14th and 15th instants (the last date on which guns could be received) and docket any guns coming in on those dates, after which it adjourned to meet Monday, the 17th instant at 10.30 a. m.

In accordance with the above, on the 14th, a representative of Messrs. Munn & Co., of New York, made personal and written application for the entry upon the docket of a gun expected by them from Vienna, Austria, which had not yet arrived.

On the 15th, Mr. Trabue presented a new gun of his invention for examination and test, which was entered upon the docket as No. 41.

NEW YORK CITY, *July* 17, 1882.

Board met pursuant to adjournment.

Present, Colonel Brooke, Captains Shorkley, Litchfield, and Greer, and the recorder.

Absent, Captain Benteen (sick).

The Board then proceeded with the testing of the Burton guns, Nos. 37 and 38, with results as stated in the synopsis.

The communication of Messrs. Munn & Co., of the 14th instant, in reference to the Schulhof gun, was referred to the War Department for instructions in the case, after which the Board adjourned to meet to-morrow at 10 a. m.

NEW YORK CITY, *July* 18, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board took up and proceeded with the testing of the Springfield-Jones gun, No. 39, with results as stated in the synopsis, after which it adjourned to meet to-morrow at 10.30 a. m.

NEW YORK CITY, *July* 19, 1882.

Board met pursuant to adjournment.

Present, all the members.

Absent, the recorder (excused).

The Board continued the testing of the Jones gun, No. 39, with results as stated in the synopsis, after which it adjourned to meet to-morrow at 10 a. m.

NEW YORK CITY, *July* 20, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board proceeded with the testing of the Russell-Livermore gun, No. 40, with results as stated in the synopsis.

The Board then adjourned to meet Monday, the 24th instant, at 10 a. m.

NEW YORK CITY, *July* 24, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board considered the subject of supplementary tests, examining the record, &c., after which it adjourned to meet to-morrow at 10.30 a. m.

NEW YORK CITY, *July* 25, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board continued the testing of guns Nos. 36 and 40, putting them in the rust bath at 12 m., after which it adjourned to meet at 10.30 a. m. the 26th instant.

NEW YORK CITY, *July* 26, 1882.

Board met pursuant to adjournment.

Present, Colonel Brooke, Captains Shorkley, Benteen, Litchfield, and Greer, and the recorder.

Mr. Trabue appeared before the Board and expressed a desire to withdraw his gun, No. 41, submitted July 15. After deliberation the Board decided to grant Mr. Trabue's request. The gun was then delivered to him without having been submitted to test of any kind.

The Board then adjourned to meet at 10.30 a. m. the 27th instant.

New York City, *July* 27, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board continued the testing of the Lee gun, No. 36, and Russell-Livermore gun, No. 40, with results as stated in the synopsis.

To enable the recorder to make up a consolidated synopsis of the primary tests of all the guns submitted, the Board adjourned to meet Monday, the 31st instant, at 10.30 a. m.

New York City, *July* 31, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board considered the subject of supplementary tests, examining the records, and handling the models, after which it adjourned to meet to-morrow at 10.30 a. m.

New York City, *August* 1, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board continued the consideration of the subject of supplementary tests.

A request to the Chief of Ordnance for special ammunition for use in supplementary tests was sent, after which it adjourned to meet Thursday, the 3d instant, at 10.30 a. m.

New York City, *August* 3, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board continued the consideration of the subject of supplementary tests, and adopted the following resolution:

Resolved, That the supplementary tests heretofore determined upon be modified as follows:

SUPPLEMENTARY TESTS.

1st. To be fired with two defective cartridges, Nos. 1 and 2, and then to be dusted five minutes, the mechanism being in the mouth of the blow-pipe, and closed, the hammer being at half-cock; then to be fired six shots, the last two defective Nos. 1 and 2; then, without cleaning, to be dusted with the breech open and fired four shots. The piece to be freed from dust only by pounding or wiping with the bare hand.

2d. To be fired five rounds with the service cartridge; then, without cleaning, and magazine filled, to be fired five rounds with 120 grains powder and a ball weighing 1,200 grains; the gun to stand twenty-four hours after firing without cleaning, and then to be thoroughly examined.

3d. Facility of manipulation by members of the Board.

4th. Liability to accidental explosions of cartridges in the magazine.

A. Magazine to be filled with each of the four kinds of cartridges on hand and shut off. Then to be fired one hundred rounds, as a single loader, in the fixed rest, using the heavy Frankford cartridges (70-500 grains) in the chamber to obtain greatest recoil when practicable. The cartridges in the magazine to be examined and changed after each fifty shots.

B. Same as in A, except the magazine being half filled.

C. Same as in A, except the gun suspended by wires so as to permit greatest extent of recoil.

5th. Test strength of parts by dropping, &c.

That the following guns, appearing to combine in each the most desirable and complete systems adapted for military use, be submitted to the foregoing tests with a view to determining as nearly as practicable which of the six will best meet the requirements of the service, viz: Marlin, No. 28; Remington-Keene, No. 30; Chaffee-Reece, No. 33; Hotchkiss, No. 34; Spencer-Lee, No. 35; Lee, No. 36.

NEW YORK CITY, *August* 7, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board proceeded with the comparison of the records, and the ammunition for the supplementary tests not having been received, adjourned to meet to-morrow at 10.30 a. m.

NEW YORK CITY, *August* 8, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The ammunition for the supplementary tests not having arrived, and there being no further business before it, the Board adjourned to meet Thursday the 10th instant, at 10.30 a. m.

NEW YORK CITY, *August* 10, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The ammunition for the supplementary tests not having arrived, and the advices indicating that it would not be here for several days, and the Board having no other business before it, adjourned to meet Monday, the 14th instant, at 10.30 a. m.

NEW YORK CITY, *August* 14, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board continued the testing of the Burton gun, No. 37, with results as stated in the synopsis. After which it adjourned to meet to-morrow at 10.30 a. m.

NEW YORK CITY, *August* 15, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board proceeded with the supplementary testing of guns No. 28 and No. 30, with results as stated in the synopsis, after which it adjourned to meet to-morrow at 10.30 a. m.

NEW YORK CITY, *August* 16, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board proceeded with the supplementary testing of the Marlin gun No. 28, with results as stated in the synopsis.

The president of the Board having been ordered to Newport Barracks, Kentucky, on court-martial duty, the Board adjourned to meet at the call of the president on his return.

NEW YORK CITY, *August* 28, 1882.

Board met pursuant to adjournment, at the call of the president.

Present, all the members and the recorder.

The Board continued the supplementary testing of the Remington-Keene gun, No. 30, and took up the Hotchkiss gun, No. 34, with results as stated in the synopsis. After which the Board adjourned to meet to-morrow at 10.30 a. m.

NEW YORK CITY, *August* 29, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board continued the supplementary testing of the Hotchkiss gun, No. 34, and took up the Chaffee-Reece gun, No. 33, also the Lee gun, No. 36, with results as stated in the synopsis, after which the Board adjourned to meet to-morrow at 10.30 a. m.

NEW YORK CITY, *August* 30, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board finished the testing of the Hotchkiss gun, No. 34, and also of the Chaffee-Reece gun, No. 33, with results as stated in the synopsis. After which the Board adjourned to meet to-morrow at 10.30 a. m.

NEW YORK CITY, *August* 31, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board took up the Spencer-Lee gun, No. 35, and submitted it to the first and second supplementary tests, and also finished with the testing of the Lee gun, No. 36, with results as stated in the synopsis, after which the Board adjourned to meet to-morrow at 10.30 a. m.

NEW YORK CITY, *September* 1, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board finished the supplementary testing of the Spencer-Lee gun, No. 35, with results as stated in the synopsis, after which the Board adjourned to meet Tuesday, the 5th instant, at 10.30 a. m.

NEW YORK CITY, *September* 5, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board proceeded with the examination of the records, and agreed upon the form of its report.

At the request of Captain Benteen, a letter was addressed to the Adjutant-General of the Army, stating that the work of the Board was finished (with the exception of signing of the report), and recommending that Captain Benteen be relieved from duty on the Board and returned to his regiment.

The Board then adjourned to meet Monday, the 11th instant, at 10.30 a. m.

NEW YORK CITY, *September* 11, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board proceeded with the examination of the record of proceedings, drawings, and descriptions of guns so far as completed, after which it adjourned to meet to-morrow at 10.30 a. m.

NEW YORK CITY, *September* 12, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The following order from the War Department, relieving Captain Benteen from duty as a member of the Board, was received and filed:

[Special Orders No. 210.—Extract.]

HEADQUARTERS OF THE ARMY,
ADJUTANT-GENERAL'S OFFICE,
Washington, September 9, 1882.

* * * * * * *

2. By direction of the Secretary of War, Captain Frederick W. Benteen, Seventh Cavalry, is relieved from duty as a member of the board of officers appointed by General Orders No. 31, March 21, 1881, from this office, and will proceed to join his troop.

* * * * * * *

By command of General Sherman:

R. C. DRUM,
Adjutant-General.

Official:
S. N. BENJAMIN,
Assistant Adjutant-General.

The Board continued the business of yesterday, after which it adjourned to meet to-morrow at 11 a. m.

NEW YORK CITY, *September* 13, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board continued the business of yesterday, after which it adjourned to meet to-morrow at 11 a. m.

NEW YORK CITY, *September* 14, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board continued the business of yesterday, after which it adjourned to meet Monday, the 18th instant, at 11 a. m.

NEW YORK CITY, *September* 18, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board continued the business of the last meeting, after which it adjourned to meet to-morrow at 11 a. m.

NEW YORK CITY, *September* 19, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board continued the business of yesterday, after which it adjourned to meet to-morrow at 11 a. m.

NEW YORK CITY, *September* 20, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board continued the business of yesterday, after which it adjourned to meet to-morrow at 11 a. m.

NEW YORK CITY, *September* 21, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board continued the business of yesterday, after which it adjourned to meet Tuesday, the 26th instant, at 11 a. m.

NEW YORK CITY, *September* 26, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board proceeded with the examination of the record, after which it adjourned to meet to-morrow at 11 a. m.

NEW YORK CITY, *September* 27, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board proceeded with the examination of the record, after which it adjourned to meet to-morrow at 11 a. m.

NEW YORK CITY, *September* 28, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board proceeded with the examination of the record, after which it adjourned to meet to morrow at 11 a. m.

NEW YORK CITY, *September* 29, 1882.

Board met pursuant to adjournment.

Present, all the members and the recorder.

The Board completed the examination of its record, and, there being no further business before it, adjourned *sine die*.

JOHN R. BROOKE,
Colonel, Third Infantry, President.

S. A. DAY,
First Lieutenant Fifth Artillery, U. S. A., Recorder.

List of guns submitted, with exhibitor's address.

No.	Name.	Exhibitor's address.
1	Remington-Keene	E. Remington and Sons, 570 State street, Springfield, Mass.; or 283 Broadway, New York.
2	Do	Same as for No. 1.
3	Boch	Philip Boch, 3 East Seventy-sixth street, New York.
4	Hotchkiss	Winchester Arms Company, New Haven, Conn.
5	Do	Same as for No. 4.
6	Chaffee-Reece	General J. N. Reece, Springfield, Ill.
7	Boch	Same as for No. 3.
8	Remington-Keene	Same as for No. 1.
9	Hotchkiss	Same as for No. 4.
10	Lee	Lee Arms Company, Ilion, N. Y.
11	Do	Same as for No. 10.
12	Trabue	William Trabue, Louisville, Ky.
13	Boch	Same as for No. 3.
14	Russell	A. H. Russell, Fort Union Arsenal, Fort Union, N. Mex.
15	Boch	Same as for No. 3.
16	Marlin	Marlin Fire Arms Company, New Haven, Conn.
17	Russell	Same as for No. 14.
18	Boch	Same as for No. 3.
19	Trabue	Same as for No. 12.
20	Boch	Same as for No. 3.
21	Trabue	Same as for No. 12.
22	Dean	Private Charles J. Dean, First Cavalry, Fort Walla Walla, Washington Ter.
23	Do	Same as for No. 22.
24	Spencer-Lee	J. W. Frazier, 290 Broadway, New York.
25	Dean	Same as for No. 22.
26	Boch	Same as for No. 3.
27	Remington-Keene	Same as for No. 1.
28	Marlin	Same as for No. 16.
29	Remington-Keene	Same as for No. 1.
30	Do	Do.
31	Spencer-Lee	Same as for No. 24.
32	Dean	Same as for No. 22.
33	Chaffee-Reece	Same as for No. 6.
34	Hotchkiss	Same as for No. 4.
35	Spencer-Lee	Same as for No. 24.
36	Lee	Same as for No. 10.
37	Burton	W. G. Burton, 23 Irving Place, Brooklyn, N. Y.
38	Do	Same as for No. 37.
39	Springfield-Jones	J. Sheridan Jones, Menno, Dakota Ter.
40	Russell-Livermore	Same as for No. 14.

REMINGTON-KEENE MAGAZINE GUN, NO. 1.

(Plate I.)

DESCRIPTION.

This gun belongs to that system in which a fixed chamber is closed by a bolt by direct action, and in which the lock is concealed.

The receiver, shown in Fig. 1, is cut through at the rear for the breech-bolt, and at the side for the handle when the bolt is locked.

The breech-bolt is composed of three parts, viz, the body or locking tube A, Fig. 2; the cocking-piece B, Fig. 3; and that (C, Fig. 4) which serves to connect the other two.

The extractor, Fig. 1, lies in a groove just in front of the rib of the locking-tube. Its tenon, D, enters a recess in the side of the tube.

The rib is bored out for a spiral spring and spindle, E and F, Fig. 1, the latter of which bears against the rear of the extractor, which is turned up nearly at right angles to its length, holding the front down on the cartridge head.

When the bolt is unlocked the extractor rides around the head of the cartridge. The ejector, Fig. 5, which is attached to the front face of the locking-tube, is pierced for the point of the firing-pin. Its upper extremity is pivoted to the bolt, while its lower is free to move to the front when struck by the carrier-lever G, Fig. 1, when the bolt is withdrawn. In that case the extractor pulls on the upper side of the cartridge, while the under side is struck by the ejector. The effect is to throw the shell clear of the gun.

The cocking-piece is terminated at front by the firing-pin, Fig. 6, secured to it by a small pin at right angles to its axis. It is hollowed out for the firing-pin spring, which bears on the rear of the firing-pin at front, and at rear on a screw at right angles to the axis of the spring, through the part C of the bolt. The cocking-piece is provided with half and full cock notches. A projection, H, on the cocking-piece enters a recess, I, on the rear of the locking-tube. The form of this projection and its corresponding recess is such as to cam back the cocking-piece when the bolt is unlocked, far enough to permit the half-cock notch to pass beyond the sear at the same time withdrawing the point of the firing-pin within the face of the bolt. The piece may be full-cocked in the ordinary manner by the hammer or cocking-lever N, Figs. 1 and 7, which is connected with the cocking-piece proper by the link O, Figs. 1 and 8.

The piece may also be cocked by drawing back the bolt and then returning it to its locking position. The bolt is prevented from being unlocked at half-cock by the point of the spindle in the axis of the handle entering the recess T in the cocking-piece. The spindle is held down by a spiral spring which gets its bearing on the screw K.

A fly, P, Figs. 1 and 12, causes the rear to ride over the full to the half cock notch when the bolt is closed, thus automatically locking it.

The magazine is in the tip-stock. The carrier is pivoted on a strong screw through the side of the receiver. Its lever works in a groove in the bottom of the locking-tube; when the bolt is withdrawn the front end of the groove strikes on the lever and tips the carrier up in a position oblique to the axis of the bore, bringing the point of the cartridge opposite the center of the chamber. The carrier is held in this position by the catch L, which springs over a pin on the inner surface of the receiver. When the bolt is closed its front presses against the catch and releases it, while the rear end of the groove in the bottom of the locking-tube strikes the carrier-lever and causes the carrier to descend opposite the mouth of the magazine.

A magazine cartridge-stop, Fig. 11, is located on the left side of the receiver. One extremity partly covers the mouth of the magazine, while the other projects through the side of the receiver so as to come in contact with the bolt. The flat spring holds it in place. When the bolt is locked the end of the stop within the receiver enters the groove in the bottom of the bolt, as seen in Fig. 10. When the bolt is unlocked the side of the groove presses down on this end and the stop moves downward, as in Fig. 9, permitting a cartridge to come out of the magazine on the carrier.

The stop is so constructed that a projection on its upper side descends just in front of the rim of the cartridge as the lower part falls in rear of it, so that the escape of a second cartridge is prevented. When the bolt has been withdrawn the spring returns the stop to its first position. A magazine cut-off, M, is provided, which works in connection with the cartridge-stop. A projecting arm of the cut-off may be made to enter a recess in the upper extremity of the stop and hold the latter clear from the operation of the bolt.

The magazine is loaded from below, and in any position of the bolt.

As a magazine gun, three motions are necessary to operate it, viz, opened, closed, fired.

As a single loader, four motions are necessary, viz, opened, loaded, closed, fired.

This gun carries eight cartridges in the magazine and one in the chamber.

SYNOPSIS OF TESTS.

Safety test.

The gun was fired in this test by Mr. Whipple (representing the Remington Arms Company), firing 10 shots in 21 seconds.

REGULAR TESTS.

I.—RAPIDITY WITH ACCURACY.

Twenty-five shots were fired, leaving 7 cartridges in the magazine, making 18 hits, 1 misfire.

As a single shooter.

Thirty-six shots were fired, leaving 1 in the chamber, making 13 hits.

II.—RAPIDITY AT WILL.

Seventeen shots were fired, leaving 6 in the magazine. One cartridge was supposed to have escaped slightly from the magazine during this test, preventing the descent of the carrier, and causing a slight loss of time, about two seconds. Mr. Whipple, the exhibitor, stated that this was caused by the momentum of the cartridge in being rapidly carried up.

As a single shooter.

Twenty-one shots were fired.

III.—ENDURANCE.

Five hundred shots were fired.

The 113th shot missed fire; went on third trial.

The 253d shot missed fire; went on second trial.

The 395th shot missed fire; went on second trial.

The 430th shot missed fire; went on second trial.

After firing the second 50 rounds, on inspection it was found that the screw securing the locking-plunger and spring in place in the bolt-handle was working loose. This was left as found, and the test continued. At 300 shots it worked entirely out and was screwed up, remaining in place to the end of the test.

In all cases where the gun missed fire a fair indentation was found in the cartridge head, and it was thought that the failure to explode the primer was, in most cases, due to the bolt not having been entirely revolved into place, and the power of the mainspring had been partially used to complete the locking of the mechanism before the firing-pin was driven forward.

IV.—DEFECTIVE CARTRIDGES.

No. 1. Liberal escape of gas through vent and from the top of bolt.

No. 2. Result about the same as No. 1.

No. 3. Slight escape of gas through the vent. Extractor failed to draw out the shell.

V.—DUST.

Worked a little hard after the second dusting.

VI.—RUST.

A little hard to open at first, but after some handling worked well.

VII.—EXCESSIVE CHARGES.

No. 1. Eighty-five grains powder and 1 ball. Opened hard.

No. 2. Ninety grains powder and 1 ball. Opened hard.

No. 3. Ninety grains powder and 2 balls. Very hard to open. Head of shell burst.

REMINGTON-KEENE GUN, No. 2.

This gun differs from No. 1 (Plate I), before described, only in the omission of the fly P, Figs. 1 and 12.

SYNOPSIS OF TESTS.

Safety test.

The gun was handled in this test by Mr. Whipple (representing the Remington Arms Company), firing the 10 shots in 19 seconds.

Regular tests.

I.—RAPIDITY WITH ACCURACY.

Thirty-one shots were fired, leaving one in the magazine, making 6 hits. Four cartridges were thrown out without entering the chamber.

As a single shooter.

Thirty-two shots were fired, making 4 hits. The operator much fatigued firing this test.

The breech opened hard, the bolt sometimes sliding forward in the way of the operator when another cartridge is being put in the chamber.

II.—RAPIDITY AT WILL.

Nineteen shots were fired, leaving 5 cartridges in the magazine; 2 cartridges were thrown out by carrier.

As a single shooter.

Twenty shots were fired.

III.—ENDURANCE.

Five hundred shots were fired; 2 misfires; went on second trial.

IV.—DEFECTIVE CARTRIDGES.

No. 1. Liberal escape of gas from above and below. Paper was much torn and blackened.

No. 2. About the same as No. 1.

No. 3. No escape of gas except at the "vent," where the paper was torn. The extractor failed to bring out the shell.

V.—DUST.

The extractor failed to bring out the first shell on first trial.

Second dusting.

The extractor failed to bring out the first shell until the fifth trial. The head of shell burst.

VI.—RUST.

The gun opened easily and worked well through the test.

VII.—EXCESSIVE CHARGES.

No. 1. Eighty-five grains powder and 1 ball. Opened hard.

No. 2. Ninety grains powder and 1 ball. Opened hard.

No. 3. Ninety grains powder and 2 balls. Gun opened very hard. Head of shell burst.

BOCH GUN, No. 3.

(Plate V.)

DESCRIPTION.

This gun belongs to that system in which a fixed chamber is closed by a bolt by direct action, and in which the lock is concealed.

The stock is in a single piece, extending nearly to the end of the barrel, and secured to it by bands held in place by springs.

The tang-screw A, Fig. 1, and the screw B, which passes into the receiver, secure the latter to the stock. The trigger-guard is fastened by the screws C and D.

The receiver, Fig. 1, has two longitudinal holes, one on each side. The opening on the left side is for the ejection of empty shells, and the one on the right side, Fig. 2, is for the introduction of cartridges, whether used as a magazine gun or as a single loader. The latter opening has at its ends two projections, E and F, Fig. 1, which fit to corresponding surfaces on the magazine when the latter is attached.

The receiver is perforated at its rear for the reception of the breechbolt.

The latter consists of three parts, viz, the rear piece, Fig. 4, through which the firing-pin, Fig. 6, passes, the projection G of the pin fitting into the cut H, Fig. 4; the locking-tube, including the handle, Fig. 3, and the bolt-head or body, Fig. 5, through which the firing-pin passes, and which supports the cartridge at the instant of fire.

The firing-pin having been introduced into the rear piece, Fig. 4, is then passed through the firing-pin spring; the movable shoulder, Fig. 9, is then, by sufficiently compressing the spring, introduced over the head of the pin, and by giving it a quarter turn is retained on the pin bearing against the shoulders I, Fig. 6, of the latter.

The spring is then held compressed between the ends J, Fig. 4, of the rear piece and the movable shoulder, Fig. 9.

The firing-pin and spring are then passed through the locking-tube, Fig. 3, and then through the bolt-head, Fig. 5, which is screwed to the rear piece.

The locking-tube has two projections, K, Fig. 3, which, when the handle of the bolt is turned down in the receiver, fit into two recesses, L, Fig. 1, in the latter, and the bolt is thereby held in position.

When the handle of the bolt is turned up from the locked position, the curved surface of the cut M, Fig. 3, cams back the firing-pin by means of the projection G, Fig. 6 (which slides in the cut), and the latter then rests in the notch N, Fig. 3, and the piece is cocked.

When the handle is turned down the cut M is brought opposite to the projection G, Fig. 6, which, released from the notch N, Fig. 3, is held by the nose of the sear; hence the firing-pin cannot reach the cartridge until the bolt-handle is turned down, and accidental explosions are therefore avoided.

The bolt-head, Fig. 5, carries the extractor, Fig. 7, which is fastened to it by means of the dovetail tenon O, which fits into a recess in the bolt-head. The bolt-head is prevented from turning by a projection, T, fitting into a groove in the receiver.

The sear P, Fig. 1, is notched at Q, for the nose of the trigger. The sear spring is attached to the under side of the tang by the screw R, Fig. 1. The trigger when pulled releases the projection G of the firing-pin, Fig. 1, and the cartridge is exploded.

The extractor, Fig. 7, hooks on the rim of the cartridge when the bolt is closed, and, when it is withdrawn, throws out the empty shell through the hole in the left side of the receiver by deflecting it from the axis of the chamber.

The magazine is shown in Fig. 11. This is attached to the right side of the receiver, as shown in the figure, and is operated by the wheel S, which, when a cartridge is to be introduced, is turned so that a cartridge can drop into the receiver, when the bolt then pushes it into the chamber.

The magazine holds twenty cartridges.

Safety test.

The gun was handled by the inventor, who fired three shots.
The extractor failing to work, the gun was withdrawn.

HOTCHKISS GUN, NO. 4.

DESCRIPTION.

This gun was similar to that drawn and described as No. 5 (Plate III), the only difference being that No. 4 was a carbine for mounted troops.

SYNOPSIS OF TESTS.

Safety test.—The gun was handled in this test by Mr. Albee, representing the Winchester Arms Company.

First trial.—Extractor failed at the fourth shot.

Second trial.—Time, 18¼ seconds. The last four rounds being fired using the arm as a single shooter. The extractor failed once, but brought out the shell at the second trial.

Regular tests.

I.—RAPIDITY WITH ACCURACY.

First trial.—The extractor failed to work and was changed.

Second trial.—Thirty-one shots were fired, making 11 hits.

As a single shooter.

Forty-one shots were fired, making 8 hits.

II.—RAPIDITY AT WILL.

Sixteen shots were fired, leaving 5 in the magazine.

The hand of the operator twice cut off the magazine by striking the ear.

As a single shooter.

Twenty-four shots were fired.

III.—ENDURANCE.

Five hundred rounds were fired; 1 misfire; went on second trial.

IV.—DEFECTIVE CARTRIDGES.

No. 1. Slight escape of gas; paper torn.
No. 2. Same as No. 1.
No. 3. No escape of gas.

V.—DUST.

Five failures to extract shells. In each case the extractor cut away a piece of the cartridge head. After the second dusting, gun worked well.

VI.—RUST.

Gun opened hard, but worked well during the test.

VII.—EXCESSIVE CHARGES.

No. 1. Eighty-five grains of powder and 1 ball. Worked well.
No. 2. Ninety grains of powder and 1 ball. Worked well.
No. 3. Ninety grains of powder and 2 balls. Gun worked stiffly at close of trial. The head of shell burst and failed to extract.

HOTCHKISS GUN, No. 5.

(Plate III.)

DESCRIPTION.

This gun belongs to that system in which a fixed chamber is closed by a bolt by direct action, and in which the lock but not the hammer or cocking-piece is concealed.

The receiver shown in Fig. 1 is cut through at the rear for the reception of the bolt; it is also cut away at the right-hand side to receive the handle of the bolt when closed, and to permit the ejection of the empty shells towards the right elbow of the operator when firing.

The breech-bolt is composed of three parts, viz, the locking-tube, Fig. 3, of which the handle forms a part; the bolt-head, Fig. 5, and the rear portion or cocking-piece, Fig. 2, to which the firing-pin is secured by a screw-thread.

The body of the locking-tube is hollowed out for the firing-pin and spring; the latter bears on a shoulder near the rear end of the locking-tube.

The bolt-head, which supports the cartridge at the instant of fire, carries the extractor, Fig. 10, which is attached to its side by means of a dovetail tenon. On the bolt-head is a projection, C, which, turning in a groove, T, in the body of the bolt, serves to hold the two parts together.

The cocking piece is held in contact with the locking-tube by the tension of the mainspring. The firing-pin, Fig. 14, is flattened near its front end. The bolt-head is prevented from turning about the pin when the bolt is withdrawn by the tenon of the extractor, which extends into the firing-pin hole nearly to the flattened surface of the pin. A projection, E, on the bolt-head enters a corresponding recess in the receiver, when the bolt is closed; consequently the bolt-head cannot turn when the body of the bolt is rotated about its axis, as in the act of closing the bolt.

The cocking-piece is shown in Fig. 2. A projection, F, fits in a recess, G, on the rear of the locking-tube; the form of the projection and its corresponding recess is such that when the bolt is opened the cocking-piece is cammed back beyond the nose of the sear or upper extremity of the trigger, withdrawing the point of the firing-pin within the face of the bolt-head. When the bolt is closed by turning down its handle, the mainspring is compressed; by pressing on the trigger the sear is drawn from the cocking-piece, and the firing-pin, driven forward by the mainspring, explodes the cartridge.

The form of the side cut in the receiver is such that the breech-bolt is cammed forward as the handle is turned down, forcing the cartridge into the chamber. As the firing-pin cannot reach the cartridge until the bolt is entirely closed and the trigger pulled, accidental discharges are avoided.

The shape of the cut at U, Fig. 1, is such as to cam back the bolt when the handle is raised, starting the empty shell; the shells are thrown out on the side of the receiver, which is cut away. The extractor being on the same side, the shells are unsupported against its side-pull the instant they leave the chamber; their front ends being consequently deflected from the axis of the receiver, they are thrown smartly to the right and fall to the ground.

The magazine is in the butt-stock. A hole is drilled in the receiver at its rear and below the breech-bolt, oblique to the axis of the bore, as in Fig. 1; through this hole cartridges are fed from the magazine into the chamber; turning down the handle in the act of closing the bolt, forces them exactly into place.

The trigger, shown in Fig. 9, bends around the magazine-tube. It bears on its upper surface the sear S and the projection K; the latter bears against the lower side of the bolt when it is not completely closed ready for firing, thus preventing any movement of the trigger or cartridge-stop, and any escape of cartridges from the magazine. The rear end of the cocking-piece is cut away on the under side to permit movement of the trigger when the bolt is closed.

The cartridge-stop is shown in Fig. 11. When the magazine is filled, which is done by pressing the cartridges into it from the receiver, they bear against the stop, as shown in Fig. 1. By pressing on the trigger the stop is depressed below the level of the magazine, and the cartridge nearest the chamber is pushed by the magazine-spring past the stop against the under side of the bolt. When the bolt is drawn back the cartridge slips quickly into the receiver, while the one following it is caught and detained by the cartridge-stop, which has only been depressed during the time that the trigger has been drawn back. It will be seen, therefore, that the pressing of the trigger to fire one cartridge permits the next one to partly enter the receiver, the operation being completed when the bolt is withdrawn with the empty shell.

The magazine cut-off is shown in Fig. 7; it has the end of its axis cut away upon one side to allow the passage of the cartridges from the magazine, but by pushing forward the thumb-piece, the edge of the cut on the partially rotated axis bears against the rim of the forward cartridge and prevents it from feeding into the chamber when the trigger is pulled and the cartridge stop depressed.

The bolt-lock, shown in Fig. 8, is on the left side of the receiver, opposite and apparently symmetrical with the cut-off; but on the end of its axis it has two transverse cuts, leaving a shoulder which engages with a recess in the trigger when the thumb-piece is pushed forward, preventing all movement of trigger, cartridge-stop, or bolt, and securely locking the gun.

This gun carries five cartridges in the magazine and one in the chamber.

As a magazine gun three motions are necessary to operate it, viz, opened, closed, fired. As a single loader four motions are necessary, viz, opened, loaded, closed, fired.

SYNOPSIS OF TESTS.

Safety test.

The gun was handled in this test by Mr. Albee (representing the Winchester Arms Company), firing the 10 shots in 16½ seconds.

Regular tests.

I.—RAPIDITY WITH ACCURACY.

Twenty-five shots were fired, leaving 2 cartridges in the magazine and making 8 hits.

In this test the magazine was twice shut off by the hand of the operator accidentally striking the ear in working the bolt.

As a single shooter.

Forty-two shots were fired, making 15 hits.

II.—RAPIDITY AT WILL.

Nineteen shots were fired.

As a single shooter.

Twenty-six shots were fired.

III.—ENDURANCE.

Five hundred rounds were fired; 1 misfire; went on second trial, a good indentation having been made the first.

IV.—DEFECTIVE CARTRIDGES.

No. 1. Liberal escape of gas; paper torn.
No. 2. About the same as No. 1.
No. 3. Slight escape of gas on top; paper not torn.

V.—DUST.

The gun worked very well. On dismounting the piece prior to cleansing for the rust test, it was found that the mainspring was broken.

At what stage of the foregoing tests this had occurred could not be determined; but as the piece seemed to be still effective, it was continued through the following tests without replacing the broken mainspring.

VI.—RUST.

The gun worked stiffly, but the 20 shots were fired without much difficulty.

VII.—EXCESSIVE CHARGES.

No. 1. Eighty grains powder and 1 ball. Gun worked well.
No. 2. Ninety grains powder and 1 ball. Gun worked well.
No. 3. Ninety grains powder and 2 balls. Missed fire twice; went on second trial. The gun worked stiffly after second trial.

THE CHAFFEE-REECE MAGAZINE GUN, No. 6.

(Plate IV.)

DESCRIPTION.

This gun is shown in section and largely in detail in Plate IV.

The receiver, Fig. 1, is bored longitudinally for the reception of the breech-bolt; it is also cut away at the side to afford a shoulder for the handle when the bolt is locked.

The bolt is composed of two parts, viz, the body, or locking-tube, Fig. 2, and the cocking-piece or hammer, Fig. 3.

The firing-pin, Fig. 6, is screwed into the hammer, and is prevented from becoming unscrewed by a small pin, W, at right angles to its axis.

The mainspring, Fig. 7, which incloses the firing-pin, gets a bearing in front against a shoulder, A, on the pin, and in rear against the bushing B, Figs. 1 and 5, which is slipped on the pin before it is screwed into the hammer. The bushing and the body of the bolt are locked together by the interrupted-thread system, the thread in this case being a single one, alternate fourths of which are cut away as in Figs. 2 and 5. The bolt and bushing being connected, if the firing-pin be drawn back by the hammer, the main-spring will be compressed between the bushing and the shoulder on the pin.

The extractor, Fig. 14, and the bolt are so connected—a projection on the under side of the former entering a groove in the latter—as to admit of the bolt rotating beneath the extractor when the handle is turned to the locking position, while the extractor is prevented from rotating with it by the slot in the receiver which it enters. The rear of the extractor is held down by a cover, D, Figs. 1 and 4, which springs sufficiently to allow the extractor to pass over the head of the cartridge when the bolt is closed. The cover is let in the rib E of the body of the bolt, and is secured by a pin, about which it can turn through a short arc. The cover is locked, as in Fig. 1, by the short arm of the bent lever, Fig. 12, bearing on the bottom of the slot in the rib, in which case its long arm rests on the upper surface of the cover as in Fig. 1. If the long arm of the lever be raised vertically, the rear of the cover may be depressed in the slot, and, its front rising, the extractor may be removed.

When the handle is turned up to unlock the bolt the hammer is cammed to the rear by the oblique surface of its rib F, Fig. 3, bearing on the rear of the rib in the locking-tube, thus withdrawing the point of the firing-pin within the face of the bolt.

The hammer is provided with half and full cock notches.

When the piece is at the half-cock the tenon G of the spring H, Fig. 1, enters a recess, X, in the side of the bolt; the latter cannot then be raised, and the piece is in condition to be carried on the march. When the hammer is let clear down the tenon is at the forward part of the recess, one side of which is inclined to the bottom, and over which the tenon rides when the bolt-handle is raised.

A cam at the rear of the side cut on the receiver forces the bolt forward and the cartridge into the chamber as the bolt is turned to its locking position. Another cam at the front of the receiver forces the bolt back during the unlocking and starts the empty shell. The shells are thrown out that side of the receiver which is cut away, the extractor hook being on the same side. An ejector, Fig. 8, let through the opposite side of the receiver to which its rear, a flat spring, is riveted, deflects the shells from the receiver.

The magazine is in the butt-stock. A hole is bored in the receiver at its rear, below the breech-bolt, oblique to the axis of the bore, Fig. 1; through this hole the cartridges are fed from the magazine into the receiver, when the bolt forces them into the chamber.

The trigger, Fig. 13, is so curved as to pass around the magazine.

The latter consists of a metallic tube and three bars, the outer two of which, Figs. 17 and 19, as they are assembled in the tube, are provided with ratchet teeth. The bar on the right, as they are assembled in the tube, has a sliding motion, its object being to carry forward the cartridge a distance equal to the length of a single cartridge at each motion of the bolt.

The bar at the left has no longitudinal motion, as its function is to prevent the cartridges moving to the rear in the tube after they have been carried forward by the other bar.

The middle bar has a very short longitudinal motion, and is operated when the gate in the bolt-plate is opened to fill the magazine by the hook J of the gate catching against that, K, of the bar.

When the middle bar is withdrawn it causes the other bars to descend to a level with it by the inclined surfaces L and M passing over the lugs N, O, P, and Q, Figs. 17 and 19. The magazine may then be loaded through the gate, the closing of which moves the middle bar to the front, when springs, Fig. 20, on the under side of the tube, raise the ratchet bars to their place.

The sliding bar is connected by the link R with the cut-off, Fig. 15, which is in turn pivoted to an arm, S, Fig. 14, of the extractor. If then the bolt be opened, the sliding bar will move to the rear, each tooth passing behind the head of the cartridge next in rear of it. The closing of the bolt carries each cartridge its own length further to the front, the piece thus operating as a magazine gun.

If the front of the cut-off be rotated downward by pressing on its push-button T, Fig. 15, the tenon U on the link R rides out of the recess V, the sliding bar no longer operates, and the piece may then be used as a single loader.

This gun carries six cartridges in the magazine, one under the bolt and one in the chamber.

SYNOPSIS OF TESTS.

Safety test.

The gun was handled in this test by Mr. R. T. Hare, expert for the Board, who fired the 10 shots in 19 seconds.

Regular tests.

I.—RAPIDITY WITH ACCURACY.

Twenty-eight shots were fired, leaving 7 cartridges in the magazine, and making 21 hits. Two cartridges failed to feed up from the magazine on the first trial.

As a single shooter.

Thirty shots were fired, making 16 hits.

It was observed that some care was necessary in placing cartridges in the chamber in this test.

II.—RAPIDITY AT WILL.

Twenty-one shots were fired, leaving 6 cartridges in the magazine.

As a single shooter.

Twenty shots were fired.

III.—ENDURANCE.

Five hundred rounds were fired, the gun working satisfactorily throughout.

At the close of this test one of the front guard-screws was found to be broken.

IV.—DEFECTIVE CARTRIDGES.

No. 1. Paper torn and blackened from escape of gas through gas-port and around end of bolt.

No. 2. Result about the same as No. 1.

No. 3. Slight escape of gas through gas-port.

V.—DUST.

The gun worked satisfactorily.

VI.—RUST.

The gun was opened with some difficulty, but after a little manipulation worked easily. In the first few shots the cartridges were forced forward into the chamber with some difficulty.

VII.—EXCESSIVE CHARGES.

No. 1. Eighty grains powder and 1 ball. Gun worked well.

No. 2. Ninety grains powder and 1 ball. Gun worked well.

No. 3. Ninety grains powder and 2 balls. The gun opened very hard and worked stiffly, the rust having dried and hardened during the firing.

BOCH GUN, NO. 7.

Description.

This was the same as the gun drawn and described as No. 3 (Plate V), modified in the following particulars:

The chamber has been enlarged, the extractor strengthened, and the manner of operating the magazine feed changed from direct operation of the ratchet by the hand to an indirect movement of the same wheel by means of a lever, which is returned to place by the action of a coil spring.

SYNOPSIS OF TESTS.

Safety test.

The gun was handled in this test by the inventor, Mr. Boch, who fired the 10 shots in 34 seconds.

Regular tests.

I.—RAPIDITY WITH ACCURACY.

Eighteen shots were fired, leaving 2 in the magazine, these having failed to drop into the receiver at the proper time, and were carried past the opening.

The magazine was taken off the gun and 4 cartridges put in before the expiration of the two minutes, 1 minute 40 seconds being the actual time of firing the 18 shots, of which 14 struck the target.

As a single shooter.

Twenty-eight shots were fired, making 23 hits. One cartridge dropped on the ground.

II.—RAPIDITY AT WILL.

Ten shots were fired, the magazine working with great uncertainty.

At this point Mr. Boch withdrew his gun, stating that he expected to introduce another, with magazine upon a different principle.

REMINGTON-KEENE MAGAZINE GUN, NO. 8.

(Plate VI.)

DESCRIPTION.

This gun differs from No. 1 (Plate I) in the following particulars:

The extractor A, Figs. 1 and 5, Plate VI, which lies on the upper surface of the bolt, is connected with the latter in such a manner as to admit of rotation of the bolt beneath it, while the extractor itself is prevented from rotating by the slot B, at the front of the receiver, which it enters when the bolt is closed.

A tenon in the rear of the extractor enters a recess in the bolt, and is held in position by the cover C, Figs. 1 and 12, let in the upper surface of the rib D, Figs. 1 and 2.

The cover is held in place by the pin E, which passes entirely through the rib.

To admit of the extractor passing over the head of the cartridge when the bolt is closed, a spiral spring, F, Fig. 1, is placed underneath the rear end of the cover C.

This permits the rear of the cover to descend when the front of the extractor is raised, and afterwards returns it to its first position.

The ejector G, Figs. 1 and 16, has been altered in form, but its principle of operation remains the same.

This gun carries 8 shots in the magazine and 1 in the chamber.

SYNOPSIS OF TESTS.

Safety test.

The gun was handled in this test by Mr. Whipple (representing the Remington Arms Company), who on first trial fired the 10 shots in 32 seconds; second trial, 40 seconds; third trial, 40 seconds. In the last two trials 2 cartridges failed to feed up in each case.

Regular tests.

I.—RAPIDITY WITH ACCURACY.

Twenty-three shots were fired, leaving 1 cartridge in the magazine, 1 in the chamber, making 21 hits. Two cartridges failed to feed up.

As a single shooter.

Thirty-one shots were fired, making 22 hits.

II.—RAPIDITY AT WILL.

Seventeen shots were fired, leaving 3 cartridges in the magazine. Two failed to feed up.

As a single shooter.

Twenty-one shots were fired, leaving 1 cartridge in the chamber. One cartridge dropped down with the carrier. The failure to feed up was thought to be due to the bolt not being brought back far enough.

III.—ENDURANCE.

Five hundred rounds were fired.

The 390th cartridge failed to extract until the third trial. At times the cartridges were extracted with difficulty, which seemed to be relieved somewhat by first cocking the piece; otherwise the gun worked well.

IV.—DEFECTIVE CARTRIDGES.

No. 1. Liberal escape of gas through gas-ports. Paper torn and blackened.

No. 2. Result about the same as No. 1.

No. 3. Slight escape of gas.

V.—DUST.

First dusting. Fired 20 rounds; worked a little gritty.

Second dusting. Opened with some difficulty, and worked stiffly during the firing of the second 20 rounds. The cut-off became clogged with sand and prevented the working of the bolt, which was finally opened by working the carrier and cut-off together. On dismounting the gun after this test, the ejector pin was found to be broken, but was not renewed.

VI.—RUST.

The gun opened easily and worked all right, excepting a slight stiffness or clogging in the carrier, preventing filling the magazine until the carrier was forced well up. On inspection, after firing the 20 rounds, it was found that the bolt could be withdrawn when supposed to be locked, and at half-cock on closing.

VII.—EXCESSIVE CHARGES.

No. 1. Eighty grains powder and 1 ball. Gun worked well.

No. 2. Ninety grains powder and 1 ball. Gun worked well.

No. 3. Ninety grains powder and 2 balls. Opened very hard, effected by striking bolt handle with the boot-heel.

HOTCHKISS GUN, No. 9.

(Plate VII.)

DESCRIPTION.

This is the same gun as No. 5 (Plate III) of the same name, modified in the following particulars:

The extractor, Fig. 10 (Plate VII), has been strengthened, and the ear of the magazine shut-off, Fig. 7, and also that of the locking device, Fig. 8, have been beveled and roughened by checking.

SYNOPSIS OF TESTS.

Safety test.

The gun was handled in this test by Mr. Albee (representing the Winchester Arms Company), who fired the 10 shots in 15 seconds.

Second trial: 14 seconds.

Regular tests.

I.—RAPIDITY WITH ACCURACY.

Thirty-two shots were fired, leaving 1 in the magazine, making 25 hits. The magazine was once cut off by the sleeve of the operator catching on the ear.

As a single shooter.

Forty-three shots were fired, making 15 hits.

II.—RAPIDITY AT WILL.

Nineteen shots were fired, leaving 5 cartridges in the magazine.

As a single shooter.

Twenty-seven shots were fired; 2 cartridges were dropped on the ground by the operator.

III.—ENDURANCE.

Five hundred rounds were fired.

The 365th cartridge caught under the bolt in feeding up, but being put back into the magazine, fed up all right.

IV.—DEFECTIVE CARTRIDGES.

No. 1. Liberal escape of gas through ports.
No. 2. About the same as No. 1.
No. 3. Slight escape of gas around head of the bolt.

V.—DUST.

Fired 40 rounds: Opened easily and worked well.

VI.—RUST.

Slightly rusted, and being still moist, opened easily and worked well throughout the test.

VII.—EXCESSIVE CHARGES.

No. 1. Eighty grains powder and 1 ball. Gun worked well.
No. 2. Ninety grains powder and 1 ball. Gun worked well.
No. 3. Ninety grains powder and 2 balls. Gun worked well.

LEE MAGAZINE GUN, NO. 10.

(Plate VIII.)

DESCRIPTION.

This gun differs from those of all other systems before the Board in having a detachable magazine (Figs. 1 and 7).

The receiver, Fig. 1, has a vertical slot cut entirely through it for the purpose of receiving cartridges from the magazine, which is underneath it and in front of the guard; it is also bored through longitudinally for the reception of the breech-bolt, and is cut away at the side to form a shoulder for the handle, by means of which, and a lug on the opposite side, entering a recess in the receiver, the bolt is locked.

The bolt is composed of two parts, the body, Fig. 2, and the cocking piece or hammer, Fig. 3. The firing-pin, Fig. 4, is screwed into the hammer, and is prevented from becoming unscrewed by a small pin, U, Fig. 1, at right angles to its axis.

The mainspring, which incloses the firing-pin, gets a bearing in front against a shoulder, A, on the pin, and in rear against the bushing, Fig. 5, which is slipped on the pin before it is screwed into the hammer.

The lug B of the bushing enters the slot C of the bolt, and on being pressed into the recess D, connects the bushing with the body of the bolt. If then the firing-pin be drawn back by the hammer, the mainspring will be compressed between the bushing and the shoulder on the pin.

The extractor E, Figs. 1 and 6, and the bolt are so connected by a tenon, F, Fig. 1, on the former, entering a groove in the latter, as to admit of the bolt rotating beneath the extractor when the handle is turned to the locking position, while the extractor is prevented from rotating with it by the slot G in the receiver, which it enters.

The rear of the extractor is held down by a cover, H, Fig. 1, which springs sufficiently to allow the extractor to pass over the head of the cartridge when the bolt is closed, and afterward returns it to its first position.

When the handle is turned up to unlock the bolt the hammer is cammed to the rear by the lug T on the bolt bearing against the oblique surface K of the hammer, thus withdrawing the point of the firing-pin within the face of the bolt.

The hammer is provided with half and full cock notches.

When the piece is at the half-cock the stud L, Fig. 3, enters the narrow part of the slot C in the rear of the bolt; the latter cannot then be opened, and the piece is in condition to be carried on the march.

When the hammer is let clear down, the stud lies in the wide part of the slot, and the bolt may be unlocked by raising its handle.

A cam at the rear of the side cut in the receiver forces the bolt forward and the cartridge into the chamber as the bolt is turned to its locking position.

Another cam at the front of the receiver forces the bolt back during the unlocking and starts the empty shell. The shells are thrown out at that side of the receiver which is cut away. The extractor being on the same side, the shells are unsupported against its side-pull the instant they leave the chamber.

A small ejector stud or pin, M, Fig. 1, against which the heads of the shells strike, assists in deflecting them from the receiver.

The magazine is simply a sheet-iron box of a sufficient capacity to hold five cartridges.

It contains a spring, surmounted by a plate, Fig. 8, which forces the cartridges up through the mortise in the receiver, in front of the bolt, by which they are carried into the chamber.

The magazine is held in position by the projection N, Fig. 7, entering a recess prepared for it in the receiver, and by the spring catch O, Figs. 1 and 9, which enters the notch P on its rear.

When the magazine is detached, as it must be when the piece is used as a single loader, a spring plate, Q, Fig. 10, attached at its rear to the left side of the receiver, projects through an opening in the latter to its inner surface, and partly closes the mortise through which cartridges are fed from the magazine. Cartridges are thus prevented from falling through to the ground during the act of loading.

Three motions are required to operate the piece as a magazine gun, and four as a single loader.

SYNOPSIS OF TESTS.

Safety test.

The gun was handled in this by Mr. Borchardt (representing the Lee Arms Company), who fired the 10 shots in 21 seconds, using one magazine only, and 21 shots in 33 seconds, using four magazines, starting with one in the chamber.

Regular tests.

I.—RAPIDITY WITH ACCURACY.

Using one magazine, 21 shots were fired, leaving the magazine full (5 cartridges), making 19 hits. The operator once dropped the magazine on the ground.

As a single shooter.

Twenty-seven shots were fired, leaving 1 cartridge in the chamber, all of which struck the target.

II.—RAPIDITY AT WILL.

Using one magazine. 11 shots were fired, leaving the magazine full.

As a single shooter.

Twenty-four shots were fired.

III.—ENDURANCE.

Five hundred rounds were fired, using one magazine. The gun worked stiffly during the first 300 rounds, but easily at the close of the test.

IV.—DEFECTIVE CARTRIDGES.

No. 1. Liberal escape of gas, and required a hard blow with the hand to extract the shell.

No. 2. About the same escape of gas.

No. 3. No escape of gas.

V.—DUST.

The fifth cartridge failed to feed up from the magazine until it was taken off and jarred, the magazine-spring cover having caught near the top. After the second dusting the firing-pin, with spring, &c., fell out during manipulation for the purpose of freeing the piece from dust. Cause unknown. The magazine-spring cover caught several times, as before.

VI.—RUST.

Gun fairly rusted, but still moist. Worked readily, but somewhat stiffly, during the firing of the 20 rounds.

VII.—EXCESSIVE CHARGES.

No. 1. Eighty grains powder and 1 ball. Gun worked well.

No. 2. Ninety grains powder and 1 ball. Gun worked well.

No. 3. Ninety grains powder and 2 balls. Opened very hard. Head of shell burst.

LEE GUN, No. 11.

DESCRIPTION.

This gun was identical with the Lee gun, No. 10 (Plate VIII), except that it was used, as the inventor claims is the intention with a number of magazines, four only being at hand in this trial.

SYNOPSIS OF TESTS.

Safety test.

The gun was handled in this by Mr. Borchardt (representing the Lee Arms Company), who fired the 10 shots in 12¼ seconds, using two filled magazines.

Regular tests.

I.—RAPIDITY WITH ACCURACY.

The four magazines being first filled, &c., 36 shots were fired, leaving 1 cartridge in the magazine, and making 24 hits.

As a single shooter.

Thirty-five shots were fired, leaving 1 cartridge in the chamber, and making 31 hits.

II.—RAPIDITY AT WILL.

The magazines being first filled, &c., 21 shots were fired, leaving 13 cartridges in the magazines.

As a single shooter.

Thirty-one shots were fired.

III.—ENDURANCE.

Five hundred rounds were fired, using the four magazines. Gun worked well.

IV.—DEFECTIVE CARTRIDGES.

No. 1. Liberal escape of gas through ports.
No. 2. Result, the same as No. 1.
No. 3. Very slight escape of gas.

V.—DUST.

First dusting: The 17th cartridge missed fire.
Second dusting: The gun worked well.

VI.—RUST.

Gun fairly rusted, but still moist. Opened easily and worked well.

The 12th cartridge in feeding up caught against the top of the chamber, but being pushed down went all right.

VII.—EXCESSIVE CHARGES.

No. 1. Eighty grains powder and 1 ball. Gun worked well.
No. 2. Ninety grains powder and 1 ball. Gun worked well.
No. 3. Ninety grains powder and 2 balls. Gun worked well.

The four magazines used with this gun did not appear to have interchangeable springs, which caused some difficulty in filling, the springs having been changed when the magazines were cleaned after the endurance test.

THE TRABUE MAGAZINE GUN, No. 12.

DESCRIPTION.

This gun, being the same as No. 19, is shown in Plate X.

The receiver, Fig. 1, is bored through longitudinally for the breech-bolt, in line with the barrel, and also below the barrel, in line with the magazine, which is in the tip-stock. It is also cut away at the side, forming at rear a shoulder for locking the bolt, and at the same time an opening for inserting the cartridges into the chamber or magazine, and also for ejecting the empty shells.

The bolt is composed of three principal parts, viz: the body or locking tube, Fig. 8; the cocking-piece or hammer, Fig. 10, into which the firing-pin is screwed; and the bolt-head, Fig. 6, which carries the extractor. An arm, A, of the latter, Fig. 6, is pivoted in a slot in the bolt-head; a small spiral spring bearing on the arm above the pivot causes the hook of the extractor to descend after it has passed over the head of the cartridge.

The front part of the firing-pin passes through the spiral spring and through the extractor arm.

On the rear of the locking-tube is a small projection, B, which enters a corresponding notch in the front face of the hammer. When the bolt is unlocked, the projection B, riding out of the notch, cams the hammer to the rear, withdrawing the point of the firing-pin within the face of the bolt.

The sear is shown in Fig. 5, and its operation and that of the trigger in Fig. 1. The latter is slotted to receive the sear, as seen in Fig. 9.

The magazine is loaded through the receiver. The cartridges descend an inclined arm, C, on the inner side of the guard, when a finger, D, on the under side of the bolt-head, forces them into the magazine. They are prevented from escaping from the latter by the spring-stop, E, Fig. 1, which is pivoted to the left side of the receiver and operated by the push-button, F, Fig. 2. The lower end of the stop springs through an opening in the side of the receiver just in front of the mouth of the magazine.

When the piece is to be used as a magazine gun, the push-button of the magazine-stop is pushed to the front, the first cartridge under the pressure of the magazine-spring backs up the inclined arm C of the guard until its head is checked by the notch G, Fig. 1, in the receiver.

If the bolt then be closed, the finger D of its head runs under the cartridge and raises its front, when the bolt forces the cartridge into the chamber.

When the piece is to be used as a single loader—which can only be done when the magazine is empty—the cartridge-follower, Fig. 11, runs out from the magazine and forms a floor, so to speak, to the receiver, so that the cartridge, on being inserted into the receiver, is in line with the barrel.

The closing of the bolt then forces it into the chamber.

This gun carries six cartridges in the magazine and one in the chamber.

SYNOPSIS OF TESTS.

Safety tests.

Gun was handled in this test by the inventor, Mr. Trabue, who fired the 10 shots in 22 seconds.

Regular tests.

I.—RAPIDITY WITH ACCURACY.

Eighteen shots were fired, leaving 7 cartridges in the magazine; 6 cartridges came out of the magazine and dropped on the ground in the firing; 15 shots struck the target.

On second trial 29 shots were fired, leaving a cartridge in the chamber and making 20 hits. One cartridge was reversed in the receiver in this test, due to faulty manipulation.

As a single shooter, 29 shots were fired, making 20 hits, and leaving 1 in the chamber.

II.—RAPIDITY AT WILL.

Sixteen shots were fired, leaving 7 cartridges in the magazine.

As a single shooter.

Twenty-two shots were fired.

III.—ENDURANCE.

Five hundred rounds were fired; 1 misfire; 4 failures to extract the shell.

IV.—DEFECTIVE CARTRIDGES.

No. 1. Large escape of gas around the bolt; failed to extract shell.

No. 2. Same as No. 1.

No. 3. Escape of gas through upper gas ports. Head of cartridge very much swollen. Failed to extract.

The chamber of the gun was evidently much enlarged, and the extractor entirely failed to bring out the shells. At this point Mr. Trabue withdrew his gun.

BOCH MAGAZINE GUN, NO. 13.

DESCRIPTION.

No drawing of this gun has been made, but it does not differ essentially from No. 26, of which a drawing and description are given (Plate XII).

With the following exceptions Nos. 13 and 26 are identical:

The carrier of No. 26, as will be seen from its drawing and description, consists of two parts pivoted together, the upper part serving to maintain the cartridges parallel to the axis of the barrel, whether the carrier is in its upper or its lower position.

The carrier of No. 13 is in a single piece, and when it is raised to transfer the cartridge from the mouth of the magazine to that of the chamber it assumes a position oblique to the axis of the latter, and consequently the bolt pushes the cartridge up an incline when introducing it into the chamber. This is the case also with a number of other guns of which carriers of this description form a part.

The magazine cut-off of No. 13 also differs somewhat from that of No. 26, that of No. 13 being operated by a sliding push-button on the left side of the receiver, while that of No. 26 is operated by a slide on the right side, as explained in the description.

The spring which controls the admission of cartridges from the magazine in the case of No. 13 is single, while in the case of No. 26 it is double, consisting of two branches operating as described.

The magazine of No. 13 carries nine cartridges.

As a magazine gun three motions are necessary to operate it, viz, opened, closed, fired. As a single loader four motions, viz, opened, loaded, closed, fired.

SYNOPSIS OF TESTS.

Safety tests.

Gun was handled in this test by the inventor, Mr. Boch, who fired the 10 shots in 1 minute and 20 seconds, the gun working with uncertainty and great difficulty.

On second trial 10 shots were fired in 36 seconds; the magazine feed worked with much uncertainty, cartridges sticking in the carrier and obstructing its operation.

Regular tests.

I.—RAPIDITY WITH ACCURACY.

Fifteen shots were fired, all of which struck the target.

The gun failed to work satisfactorily, and was withdrawn for modification.

RUSSELL GUN, No. 14.

DESCRIPTION.

This was the same gun slightly modified and afterwards drawn and described as No. 17 (Plate IX).

SYNOPSIS OF TESTS.

The gun was presented by First Lieutenant A. H. Russell, of the United States Ordnance Department, who fired the safety tests, 10 shots, in 23 seconds.

Regular tests.

I.—RAPIDITY WITH ACCURACY.

Thirty-one shots were fired, making 24 hits.

Same as single shooter.

Thirty-five shots were fired, making 24 hits.

In this test six shells fell back into the receiver, and were taken out by hand, the magazine cut-off or stop being on.

Same: The magazine being filled from the cartridge cases, 19 shots were fired, leaving the magazine full. Two cartridges escaped from the magazine, in filling, and fell on the ground, the magazine failing to close promptly.

II.—RAPIDITY AT WILL.

Twenty-one shots were fired.

Same as single shooter.

Twenty-three shots were fired.

Same: The magazines being filled from the cartridge cases, 21 shots were fired.

III.—ENDURANCE.

Four hundred shots were fired; 33 miss-fires; 6 failures to eject.

After firing 100 shots the exhibitor was permitted to replace the ejector with a new one.

In the fourth 50 of shots the bolt twice pulled entirely out to rear in opening, caused by the sear-spring failing to press the sear into the notch.

After 400 shots the gun worked with great difficulty, and on inspection was decided to have broken down, and was withdrawn.

BOCH GUN, No. 15.

DESCRIPTION.

This was the same gun as No. 13, which, having been slightly modified in the form of the carrier, was re-entered as No. 15.

SYNOPSIS OF TESTS.

The gun was handled in the safety test by the inventor, Mr. Philip Boch, who fired the 10 shots in 22 seconds.

Regular tests.

I.—RAPIDITY WITH ACCURACY.

Twenty-eight shots fired, making 25 hits, leaving 4 in the magazine.

Same as a single shooter.

Thirty-four shots fired, making 29 hits.

II.—RAPIDITY AT WILL.

Nineteen shots were fired, leaving 7 in the magazine.

Same as single shooter.

Nineteen shots were fired; 1 miss-fire.

III.—ENDURANCE.

Five hundred shots were fired.

During the second series of 50 shots, the extractor became unseated.

During this test cartridges on being thrown up into the receiver sometimes caught at the top and had to be pushed down with the finger before they would enter the chamber. As the working of the gun grew harder, this was more frequently observed. One miss-fire.

IV.—DEFECTIONS.

No. 1. Large escape of gas.
No. 2. Large escape of gas.
No. 3. Slight escape of gas.

V.—DUST.

First dusting, opened and worked with some difficulty; 1 failure to extract.

Second dusting, gun worked hard; 1 cartridge failed to feed down into the carrier.

VI.—RUST.

Gun opened with great difficulty, requiring use of the mallet. The carrier failed to operate, and the gun was withdrawn.

MARLIN MAGAZINE GUN, NO. 16.

DESCRIPTION.

This gun, being the same in all respects as No. 28, is shown in section with breach opened and closed in Plate XIII.

The breech-block A, Figs. 1, 2, and 4 is operated by the lever, B, the upper end of which lies between the front shoulder, C, of the block, and an arm, D, of the firing-pin. When the lever is thrown to the front its upper extremity bears on the arm of the pin and causes the breech-block to move to the rear.

When the lever is carried to the rear the block is closed and supported against the pressure of the gas by the end of the lever bearing against the shoulder C, as seen in Fig. 1. The lever is itself supported by a strong pivot, E.

The extractor is simply a spring-hook, F, Figs. 1 and 2, on top of the barrel-block. On the sides of the block are two ribs, G, Fig. 4, which, running in grooves on the inner sides of the receiver, guide the block when it is opened and closed.

A cover, H, Figs. 1 and 2, attached to the breech-block at its rear by a small screw, N, slides in grooves in the receiver in the same manner.

The magazine is in the tip-stock and consists of the usual metallic tube, spiral spring, and cartridge follower. The cartridges are loaded in the magazine through a side gate in the receiver. They are prevented from escaping by the projecting arm J, Fig. 4, of the breech-block. When the block is opened the first cartridge, under pressure of the magazine spring, backs into the carrier, Fig. 5, the operation being a gradual one, thus avoiding shocks.

The carrier is rotated about its axis, K, Figs, 1 and 2, by the upper arm of the lever striking on its curved surface, L, thus bringing the point of the cartridge opposite the chamber. Closing of the lever and block forces the cartridge into the chamber and also depresses the carrier to the bottom of the receiver in position to receive another cartridge when the block is opened.

The piece is fired by a center lock of the usual form.

This gun carries 9 shots in the magazine and 1 in the chamber.

SYNOPSIS OF TESTS.

This gun was presented and handled in the safety test by Mr. J. J. Sweeney, who fired the 10 shots in 7 seconds.

Regular tests.

I.—RAPIDITY WITH ACCURACY.

Thirty-two shots were fired, making 18 hits and leaving 2 in the magazine. One shot was fired before bringing the piece to the shoulder

As a single shooter.

Twenty-seven shots were fired, making 22 hits.

II.—RAPIDITY AT WILL.

Twenty-three shots were fired, leaving 4 in the magazine.

As a single shooter.

Twenty shots were fired.

III.—ENDURANCE.

On firing the 48th shot a cartridge exploded in the magazine.

On examination it was found that this was the first cartridge put in at the last filling of the magazine, and at the time it exploded had one cartridge behind it. The cartridge behind it was found to be much compressed and shortened, and somewhat disturbed in shape, the bullet being driven back nearly into the shell, but this cartridge had not exploded.

The Board was of the opinion that the explosion was due to the jolting encountered in feeding down through the magazine, and the repeated blow on the base of the cartridge from the column behind it, caused by the recoil of the piece at each shot and possibly combined with an oversensitive cartridge, due to imperfect manufacture or deterioration.

The result of the explosion was the compression and carrying away of the spiral magazine spring, and also the tip piece of the stock, to the front, against the target butt, in which the bullet was found partially imbedded. The stock in front of the middle band was split; the magazine tube, of brass, slightly bulged at the point where the explosion took place; the shell was bursted and the magazine closer was bent outward by the escape of gas to the rear. No injury resulted to the shooter.

The gun was withdrawn for repairs.

RUSSELL MAGAZINE GUN, NO. 17.

(Plate IX.)

DESCRIPTION.

This gun belongs to that system in which a fixed chamber is closed by a bolt by direct action and in which the lock is concealed.

The stock consists of a single piece grooved for the reception of the barrel, to which it is fastened by two bands held in position by springs.

It is also hollowed out for the receiver and cut away at the right for the magazine, which is secured by two screws, A and B, Fig. 1, Plate IX.

The receiver, Figs. 1 and 2, is fastened to the stock by the tang screw C, Fig. 2, which passes through the stock into the trigger-guard plate. The screw D, Fig. 2, secures the front end of the guard-plate to the receiver.

The receiver is perforated at the rear for the breech-bolt.

The latter consists of four parts, viz: The rear piece or nut, Fig. 5, into which the firing-pin, Fig. 8, is screwed; the cocking-piece, Fig. 4; the bolt-body or locking tube, including the handle, Fig. 3; and the bolt-head, Fig. 7, which carries the extractor E, secured by two dove-tail tenons.

The locking-tube has on the inside a shoulder, F, Fig. 3, upon which the firing-pin spring bears, as seen at G, Fig. 2. This spring is first introduced into the locking-tube, then the firing-pin is passed through the spring, resting upon it by the shoulder, H, Fig. 8; then through the cocking piece, which is prevented from rotating by a small pin, I, Fig. 4, set in the side of the cocking-piece and forming a projection inside the latter; the flattened surface of the pin being in contact with this projection, the cocking-piece cannot turn independently of the firing-pin, nor can the latter pass any farther through the cocking-piece than the limit K, Fig. 8.

By compressing the spring, the nut, Fig. 5, is screwed to the end of the firing-pin, thus holding the spring compressed between the shoulder of the pin and the inside shoulder of the bolt-body. A small screw in the nut prevents it from becoming unscrewed from the firing-pin. The head of the firing-pin is then passed through the bolt-head; the latter is joined to the bolt-body by turning the projections L, Fig. 7, behind corresponding ones in the bolt-body; a small screw in the bolt-head bearing against the flattened surface of the pin M, Fig. 8, prevents it from turning about the pin.

The piece is cocked by turning the bolt-handle up from the locked position; in this act the curved surface N, Fig. 3, of a cut in the rear of the bolt-body cams back the firing-pin by means of the projection O, Fig. 4, which fits into the cut; when the bolt-handle is up the projection O falls into a notch, P, Fig. 3; when the handle is turned down, the cut, N, Fig. 3, is brought opposite the projection O Fig. 4, and the firing-pin, released from the notch N, is then held back by the nose of the sear which fits into the notch T, Fig. 4. When the trigger is pulled the sear is withdrawn and the firing-pin, impelled by its spring, is driven forward and explodes the cartridge. The firing-pin cannot reach the cartridge until the bolt-handle is turned down, and accidental explosions are thus avoided.

The trigger Q, Fig. 2, works about the pivot R; the sear spring is seen at S, Fig. 2.

The bolt may be locked at full cock, when the handle is turned down, by the piece shown in Fig. 6. This passes through the upper part U of the cocking-piece. The shaft V, Fig. 6, is cut away at the end, as seen at K′, so that when it is in position in the cocking-piece it may be turned by means of the thumb-piece Y, Fig. 6, so that either the concave surface of the cut K′ forms a continuation of the surface Z, Fig 4, or the convex surface of the shaft V, Fig. 6, projects beyond the surface Z. In the former case the locking-shaft has no effect; in the latter, when the piece is at full cock, and the bolt-handle down, the shaft fits into the notch A′, Fig. 3, and thus prevents the bolt from turning or the firing-pin from driving forward.

The magazine, Fig. 9, is attached, as shown in Fig. 1, to the side of the gun. The cartridges, under the influence of the magazine-spring B′ are pressed up against the bolt, and, when the latter is withdrawn, a cartridge rises until the rim presses against the piece C′, as shown in Fig. 1; when the bolt is pushed in again, the bolt-head catches the cartridge and pushes it into the chamber.

The extractor E, Fig. 7, attached to the upper side of the bolt-head, catches the rim of the cartridge in the chamber, and when the bolt is withdrawn the empty shell is extracted, and the rim falling into the notch D′, Fig. 2, is thrown out upwards.

The magazine cut-off, two positions of which are shown at E′, Fig. 2, operates by raising in the bottom of the receiver a bolt-stop, which prevents the bolt when withdrawn from going back far enough to allow the cartridge to rise, and the bolt may be locked without introducing a cartridge from the magazine. When the lever E′, Fig. 2, is in its forward position, the bolt-stop is flush with the lower surface of the receiver; but when the lever is in its rear position the stop is raised, and catching the bolt by a projection on its under surface stops the bolt and thereby also the escape of cartridges from the magazine.

The magazine is filled with cartridges by means of a small metal box, into which the cartridges are first placed, and then, by adjusting the mouth of the box to that of the magazine, the cartridges may be pushed down into the magazine by a single motion.

This gun carries five cartridges in the magazine and one in the chamber.

SYNOPSIS OF TESTS.

This was the same gun as No. 14, with some slight modifications.

The gun was handled in the safety test by the inventor, who fired the 10 shots in 26 seconds.

Regular tests.

I.—RAPIDITY WITH ACCURACY.

Thirty shots were fired in 2 minutes, making 20 hits; 1 misfire.

As a single shooter.

Twenty-nine shots were fired, making 20 hits, leaving 1 in the chamber, 1 misfire, 3 failures to eject, the shells falling back into the receiver reversed.

Same with magazine filled from cases.

Thirty shots were fired, making 22 hits, leaving the magazine full; 1 misfire.

II.—RAPIDITY AT WILL.

Twenty shots were fired; 1 misfire.

As a single shooter.

[illegible] fired.

[illegible]

[illegible] the [illegible]

[illegible]

[illegible] several [illegible]

[illegible]

[illegible] the [illegible]

[illegible]

[illegible]

[illegible]

VI.—RUST.

Gun opened and worked with difficulty, requiring the use of the mallet.

After opening, the cap to the magazine would not, at first, spring back to its place; 5 miss-fires.

VII.—EXCESSIVE CHARGES.

No. 1. Opened by use of mallet.
No. 2. Opened by use of mallet.
No. 3. Opened by use of mallet.
Extractor broken and head of shell blown nearly off, and shell taken out by use of bullet and rammer.

BOCH GUN, No. 18.

DESCRIPTION.

This was the same gun as No. 15, slightly modified.

SYNOPSIS OF TESTS.

The safety test was complied with by Mr. Boch, who fired the 10 shots in 25 seconds.

Regular tests.

I.—RAPIDITY WITH ACCURACY.

First trial. The gun failed to work, through some mistake in adjustment or manipulation on the part of the expert.

Second trial. Twenty-seven shots were fired, making 21 hits and leaving 1 in the magazine.

Six cartridges required to be pressed down in the receiver by the finger before they would enter the chamber.

Third trial. Twenty-nine shots were fired, leaving 7 in the magazine. The same difficulty observed as before.

The Board here informed Mr. Boch that the gun in its present form, in their opinion, was not suitable for military purposes, and consequently declined further examination of it.

TRABUE MAGAZINE GUN, No. 19.

(Plate X.)

DESCRIPTION.

This gun was the same previously drawn and described as No. 12, in which some of the joints were tightened to prevent too great an escape of gas. A new receiver was also substituted.

SYNOPSIS OF TESTS.

This gun was of the same pattern as No. 12, somewhat modified in the details of construction.

The safety test was complied with by Mr. Melcher, expert for Mr. Trabue, who fired the ten shots in 22½ seconds.

Regular tests.

I.—RAPIDITY WITH ACCURACY.

Thirty shots were fired in two minutes, making 19 hits.

The shells fired in this test, using the magazine, all show distortion by flattening on one side at the muzzle.

Same as single shooter.

Forty shots were fired, making 17 hits; shells not distorted in this test (as a single shooter).

II.—RAPIDITY AT WILL.

Twenty-one shots were fired in one minute, one thrown out by false motion of the operator.

Same as single shooter.

Twenty-nine shots were fired.

III.—ENDURANCE.

Five hundred shots were fired; 1 miss-fire. Gun worked well.

It was observed that the shell from the last shot of each magazine full came out without being flattened at the muzzle.

IV.—DEFECTIVE CARTRIDGES.

No. 1. Some escape of gas through the ports.
No. 2. Some escape of gas through the ports.
No. 3. No escape. Shells extracted easily.

V.—DUST.

Gun worked well.

VI.—RUST.

Gun fairly rusted; opened and worked well through the test.

VII.—EXCESSIVE CHARGES.

No. 1. Extracted, but did not eject, the extractor not fully grasping the rim of the cartridge.

No. 2. Same as No. 1.

No. 3. The gun required use of the mallet to open when it did not extract the shell.

On examination it was found that a piece of the flange or rim of the shell had pulled or blown out and lodged under the extractor in such a manner as to temporarily prevent its proper action.

On being removed, the extractor was found uninjured and worked properly.

On taking the gun apart at the close of these tests it was found that the plunger-cap in the magazine had become unsoldered and was loose in the magazine.

The gun worked without it.

BOCH GUN, No. 20.

DESCRIPTION.

This was the same gun as No. 18, slightly modified.

SYNOPSIS OF TESTS.

The safety test was complied with by the inventor, who fired the 10 shots in 13½ seconds.

Regular tests.

I.—RAPIDITY WITH ACCURACY.

Twenty-eight shots were fired, making 26 hits.

As a single shooter.

Feeding single cartridges into the magazine. Thirty shots were fired, leaving 1 in the gun, making 23 hits.

II.—RAPIDITY AT WILL.

Twenty-three shots were fired, leaving 4 in the magazine.

As a single shooter.

Twenty-three shots were fired.

Feeding into the side opening, when the magazine was full, the magazine stop or shut-off failed to prevent the cartridges in the magazine from feeding down. Inserting the cartridges at the top, however, an operation requiring an extra motion, the cartridges remained in the magazine all right.

III.—ENDURANCE.

Five hundred shots were fired.

During the fifth series of 50 shots, 4 cartridges failed to pass into the chamber, requiring their position to be corrected by the finger of the operator; 1 failure to extract, requiring the use of the rammer to drive out the shell.

In the seventh series one failure to eject the shell being driven back into the chamber, required the use of the rammer to drive it out.

Eighth series, 1 cartridge failed to pass into the chamber until its position was corrected. This trouble was observed to a greater or less extent at times during the firing of the whole 500 shots.

IV.—DEFECTIVE CARTRIDGES.

No. 1. Large escape of gas around the bolt-head to the rear.
No. 2. About the same as No. 1.
No. 3. Slight escape of gas through the ports. Failed to extract shell.

V.—DUST.

After first shot the gun opened and shell came out with great difficulty, dust having penetrated the chamber.

The same difficulty in the adjustment of the cartridges, sometimes requiring to be pushed down before they would enter the chamber, observed throughout this test as in the preceding.

VI.—RUST.

Gun opened easily, being moist, due to wet weather, and worked a little stiffly. The magazine spring seemed hardly strong enough to bring down the cartridges with certainty, but otherwise worked very well.

VII.—EXCESSIVE CHARGES.

No. 1. Eighty-five grains powder and one bullet. Head bursted, but gun opened and extracted all right.

No. 2. Ninety grains powder and one bullet. Opened and extracted all right.

No. 3. Ninety grains powder and two bullets.

Gun opened hard and failed to extract, the extractor cutting through the metal of the shell.

THE TRABUE MAGAZINE GUN, No. 21.

DESCRIPTION.

This gun is essentially the same as No. 12,* already described.

It differs from it only in the dimensions of its parts and in the addition of a set-screw for locking the bolt on the march. A projecting mass of metal on the right side of the receiver was bored and tapped for a left-handed screw. The screw instead of being slotted has a raised head, with a flat finger-piece by which it may be operated. The point of the screw enters a recess in the bolt, when the screw is turned in, and thus prevents the bolt unlocking. The set or locking screw is prevented from unscrewing by the head of a small screw which overlaps the head of the former.

SYNOPSIS OF TESTS.

The gun was handled in the safety test by Mr. Hare, who fired the ten shots in 31 seconds.

Regular tests.

I.—RAPIDITY WITH ACCURACY.

Thirty shots were fired, making 19 hits, and leaving 3 in the magazine.

Three cartridges were thrown out in filling the magazine.

Same as single shooter.

Forty-three shots were fired, making 8 hits.

II.—RAPIDITY AT WILL.

Eighteen shots were fired in one minute, leaving 5 in the magazine.

Same as single shooter.

Thirty shots were fired.

(* See Plate X.

III.—ENDURANCE.

Five hundred shots were fired.

Three hundred and fifty shots were fired, the gun working all right, except for a noticeable tendency on the part of the bolt to revolve backward, the handle starting up at each shot. As this seemed to increase as the test continued, the gun was withdrawn for slight modification, after which the test was continued, firing the remaining 150 shots in this test all right; the gun opening a little harder than before.

IV.—DEFECTIVE CARTRIDGES.

No. 1. Liberal escape of gas through the port and from around the bolt.

No. 2. About the same as No 1.

No. 3. Slight escape from gas port.

V.—DUST.

The gun opened and worked through the test all right.

VI.—RUST.

Gun but little rusted, the weather being very damp. The gun found wet; opened a little hard, too hard to be opened by the hand after a few shots. One misfire.

VII.—EXCESSIVE CHARGES.

Eighty-five grains powder and one bullet—405 grains lead. Gun opened hard, the head of the shell having bursted, but extracted the shell all right.

Ninety grains powder and two bullets; gun opened hard and failed to extract the shell; the head was blown off, and on opening dropped into the magazine.

When the gun was taken apart, a screw in the extractor was found to be bent, and a small fragment of the shell cut off by the extractor was found under it.

DEAN MAGAZINE GUN, No. 22.

(Plate XI.)

DESCRIPTION.

This gun is shown in section and largely in detail in Plate XI.

The breech-block, A, Figs. 1 and 7, is operated by the lever, B, through the intervention of the links C and D, the latter of which causes the recoil-block, E, to descend while the former forces the breech-block to the rear, when the lever is thrown to the front, as in Fig. 7.

The lock, Fig. 4, is of the usual outside pattern and needs no extended description.

Two magazines are provided—one in the butt and one in the tip-stock, either of which may be used by locking off, by means of a cut-off, the other.

The carrier, which is open at both ends to receive cartridges from either magazine, has a vertical motion at right angles to the axis of the piece. It is operated by the lever in the same general manner as the Winchester repeater, so well known in this country.

This gun carries ten cartridges in the tip stock magazine, six in the butt-stock, and one in the chamber.

SYNOPSIS OF TESTS.

This gun was handled throughout by the inventor, who fired the ten shots in the safety test from the front magazine in 8 seconds.

The same test using the rear magazine supplemented by the front, the ten shots were fired in 16 seconds.

Regular tests.

I.—RAPIDITY WITH ACCURACY.

Thirty-four shots were fired, making 9 hits, using both magazines.

As a single shooter.

Twenty-nine shots were fired, making 14 hits.

II.—RAPIDITY AT WILL.

After emptying the butt magazine, the front magazine could not be opened or turned on. It was found on inspection that the tip stock had been displaced and driven forward by the recoil of the piece from the previous shots to such an extent as to bind and prevent the working of the cut-off.

The Board decided that the inventor might correct this defect of construction, when the test would be continued. The inventor, however, preferred to withdraw the gun to make other modifications, and begin the tests again.

DEAN GUN, No. 23.

DESCRIPTION.

Same as No. 22 (Plate XI), slightly modified.

SYNOPSIS OF TESTS.

The gun was handled by the inventor, who fired the ten shots in the safety test in 8 seconds.

Regular tests.

I.—RAPIDITY WITH ACCURACY.

Thirty-four shots were fired, making 10 hits.

As a single shooter.

Twenty-six shots were fired, making 17 hits.

II.—RAPIDITY AT WILL.

Twenty shots were fired, leaving 14 in the magazine.

Same as single shooter.

At the fourteenth shot the gun broke down.

On inspection it was evident that the break was due at least in part to faulty construction.

It was observed, however, that the gun seemed to work hard through all the tests, it being necessary to take it from the shoulder and rest the butt in the groin of the operator to work the lever.

SPENCER-LEE, No. 24.

DESCRIPTION.

This is a similar gun to that afterwards drawn and described as No. 35 (Plate XVII), the difference being that in this gun, besides being lighter in some of its parts, the device for locking the hammer until the breech-block is closed, shown in Fig. 16 and at Z, Fig. 3, of No. 35, was not in this gun.

SYNOPSIS OF TESTS.

This gun was presented by Mr. J. W. Frazier, of New York, and was handled in the safety test by one of the inventors (Mr. Spencer), who fired the ten shots in 11 seconds.

Regular tests.

I.—RAPIDITY WITH ACCURACY.

Thirty-four shots were fired, making twenty-seven hits, three cartridges being passed through the gun and thrown out without firing—the operator neglecting to pull the trigger.

Second trial, by one familiar with the arm, 64 shots were fired, making 56 hits and leaving one in the chamber.

Same as single shooter.

Several trials were had before the piece could be fired beyond the first shot, on account of a difficulty in opening the gun. It was finally discovered that the trouble was due to a want of friction in the bearing of a spring, the office of which was to retain the trip in place after closing, the effect of which was to let the shell be driven back in firing, so as to protrude and take up the space necessary for the free opening of the breech. This was readily adjusted, and the trial resulted in 34 shots, making 32 hits. The gun worked very well.

II.—RAPIDITY AT WILL.

Twenty shots were fired, 5 cartridges being pumped through the gun, the operator neglecting to pull the trigger.

On a second trial, at the request of the operator, 27 shots were fired; one missed fire, and one failed to feed up from the magazine.

Same as a single shooter.

Twenty-seven shots were fired, 2 cartridges being thrown out without firing as before.

III.—ENDURANCE.

Five hundred shots were fired, during which the gun worked all right, but the cartridge frequently failed to feed up from the magazines. This difficulty was observed with some of the magazines more than others, and was not fully accounted for.

IV.—DEFECTIVE CARTRIDGES.

No. 1. Liberal escape of gas above and below.
No. 2. Liberal escape of gas above and below.
No. 3. Very slight escape.

V.—DUST.

This test seemed to have little or no effect on the working of the gun, doubtless in part due to its entire freedom from oil.

VI.—RUST.

The weather having been alternately wet, windy, and dry, the gun was very badly rusted in all of its bearings, and, as a consequence, worked very hard through the test. Three misfires.

VII.—EXCESSIVE CHARGES.

Eighty-five grains powder—1 bullet worked about as before.
Ninety grains powder—1 bullet.
Ninety grains powder—2 bullets.
Head of shell blown off and gun opened very hard, requiring the use of the mallet.

The gun having passed through the preliminary tests, was here withdrawn for modification.

DEAN GUN, No. 25.

DESCRIPTION.

This was the same gun as Nos. 22 (Plate XI) and 23, slightly modified and repaired.

SYNOPSIS OF TESTS.

It was handled in the safety test by the inventor, in firing which, at the sixth shot, the receiver bursted, breaking the gun in two—the butt falling upon the ground, the barrel being retained in the left-hand of the operator. Withdrawn.

BOCH MAGAZINE GUN, No. 26.

(Plate XII.)

DESCRIPTION.

This gun belongs to that system in which a fixed chamber is closed by a bolt by direct action, and in which the lock is concealed.

The stock is in two parts, the butt and the tip; these are joined together and to the barrel by a band which passes around the ends of the two parts, at their junction and the barrel. Another band fastens the front end of the tip-stock to the barrel.

In the right side of the butt-stock is a longitudinal opening coincident with a similar one in the receiver. Through this hole cartridges may be introduced on the carrier to be described later. The butt-stock is grooved to fit the barrel and cut through for the receiver which is fastened to the stock by means of a tang screw, A, Figs. 1 and 2, passing through the stock into the trigger-guard plate. The butt-stock is also perforated by a hole continuous with one in the tip-stock, through which the magazine tube E, Figs. 1 and 2, passes, the latter being fastened to the receiver by a screw-thread.

The trigger-guard, to which the trigger is permanently attached by a rivet, B, Figs. 1 and 2, is secured to the butt-stock by means of a screw, C, and to the receiver by a screw, D.

The receiver is perforated at its rear by a hole for the reception of the breech-bolt. The latter consists of three parts, viz: the rear pin, Fig. 7, through which the firing-pin, Fig. 3, passes, the projection F of the pin fitting into the cut G, Fig. 7; the locking-tube, including the handle, Fig. 6, and the bolt-head or body through which the firing-pin passes, and which supports the cartridge at the instant of fire.

The firing-pin having been introduced into the rear piece, Fig. 7, is then passed through the firing-pin spring; the movable shoulder H, Fig. 3, is then, by sufficiently compressing the spring, introduced over the head of the firing-pin, and, by giving it a quarter turn, is retained on the pin bearing against the projections I, Fig. 3, the spring then being held compressed between the end J, Fig. 7, of the rear piece and the movable shoulder H.

The firing-pin and spring are then passed through the locking-tube, Fig. 6, and then through the bolt-head or body, Fig. 5, which is then screwed to the rear piece.

The locking-tube has two projections, K, Fig. 6, which, when the handle of the bolt is turned down in the receiver, fit into two recesses, L, Figs. 1 and 2, in the latter, and the bolt is thereby held in position. When the handle of the bolt is turned up from the locked position, the curved surface of the cut U, Fig. 6, cams back the firing-pin by means of the projection F, Fig. 3 (which fits into the cut), and the latter then rests in the notch N, Fig. 6, and the piece is cocked.

When the handle is turned down, the cut U, Fig. 6, is brought opposite the projection F, Fig. 3, which, released from the notch N, Fig. 6, is held by the nose of the sear, as in Fig. 1, O; hence, the firing-pin cannot reach the cartridge until the bolt handle is turned down, and accidental explosions are avoided.

The bolt-head, Fig. 5, carries the extractor, Fig. 4, which is fastened to it by the tenons P and Q, which fit into the recesses R and S of the bolt-head. The latter is prevented from rotating in the receiver by a small projection in the latter which fits into a groove in the bolt-head.

The carrier, Fig. 8, receives the cartridges from the magazine, and by an upward movement elevates them to a position from which the bolt can push them into the chamber.

The carrier is in two parts; the upper one, Fig. 8, being joined to the lower by the pivot V, Fig. 8.

The projection M, of the upper part of the carrier, fits into a groove in the bolt-head, as seen in Figs. 1 and 2, M. When the bolt is drawn back the front end of the groove strikes the projection M, Fig. 2, and the carrier working about the pivot T, Figs. 1 and 2, is raised to its position in Fig 2.

The upper part of the carrier working about the pivot V is raised at its rear end by sliding up the metallic piece or dog W, Figs. 1 and 2. This piece W is attached by a pivot pin to the side of the receiver at X; its lower end rests on the lower part of the carrier, and when the latter is raised the upper part at its rear slides up the piece W, both turning about their pivots V and X, and the level position of the upper part is maintained.

The carrier in its lower position is supported by the piece N′, Fig. 1, which may, if desired, be so turned on its pivot Z as to allow the carrier to descend through the opening in the receiver, and the bolt may then be drawn entirely out of the piece.

A spring, A′, Figs. 1 and 2 attached to the outside of the receiver by the same screw that forms the pivot T, Figs. 1 and 2, acts as the cartridge detent, by means of which the admission of cartridges from the magazine is controlled. This spring consists of two branches, B′, Figs. 1 and 2, each having two projections fitting into holes in the receiver.

The carrier, Fig. 1, in its lower position, presses out the spring projection K′, the cartridge then resting against the projection I′; on raising the carrier the latter presses out the projection I′, and the cartridge, impelled by the magazine spring, now bears against L′, which has been allowed to enter by raising the carrier; when the bolt is shoved in and the carrier consequently lowered, the latter allows the stop I′ to enter beyond the rim of the first cartridge, and when the carrier reaches its lower position the detent K′ is pushed out and the first cartridge slips past to the carrier, which, on being elevated, brings it to the position from which the bolt pushes it into the chamber.

The magazine cut-off consists of a spring secured to the right side of the receiver by a screw. The free end of the spring has a small projection which enters a corresponding hole in the receiver in front of the mouth of the magazine. A slide, provided with a notch, which by moving the slide can slip under the spring and draw the projection out of the hole, operates the cut-off. When the slide is pushed forward, the mouth of the magazine is open; when it is drawn back, the projection enters the hole and cartridges are prevented from leaving the magazine.

The sear E′, is notched at F′ for the nose of the trigger. The sear-spring is attached to the under side of the tang by the screw M′, Figs. 1 and 2.

The trigger, when pulled, releases the projection F, of the firing-pin, Fig. 1, and the cartridge is exploded.

The extractor, Fig. 4, hooks on to the rim of the cartridge when the bolt is closed, and when it is withdrawn throws out the empty shell by deflecting it from the axis of the chamber.

This gun carries nine cartridges in the magazine and one in the chamber.

As a magazine gun, three motions are necessary to operate it, viz, opened, closed, fired; as a single loader, four motions, viz, opened, loaded, closed, fired.

SYNOPSIS OF TESTS.

The gun was handled in the safety test by the inventor, who fired ten shots in 12½ seconds.

Regular tests.

I.—RAPIDITY WITH ACCURACY.

Thirty-one shots were fired, making 25 hits, and leaving 6 in the magazine.

Same as a single shooter.

Thirty-three shots were fired, making 18 hits.

II.—RAPIDITY AT WILL.

Twenty-one shots were fired, leaving 6 in the magazine.

Same as a single shooter.

Twenty-one shots were fired, leaving 1 in the chamber.

III.—ENDURANCE.

The gun being put in the rest, it was found to be defective in its feeding apparatus, the cartridges in the magazine and on the carrier so interfering with each other as to frequently require the gun to be taken out and turned over and jarred before it could be opened.

After firing 50 shots the inventor was permitted to take the gun to correct this difficulty, after which the test was continued. The gun worked fairly, cartridges sometimes failing to feed down into the carrier promptly, seeming to bind in the tube; 7 misfires.

IV.—DEFECTIONS.

No. 1. Liberal escape of gas.
No. 2. Liberal escape of gas.
No. 3. Slight escape of gas.

V.—DUST.

Gun worked fairly; a little hard. Two misfires.

VI.—RUST.

Gun well rusted; worked hard, but effectively, except that nearly every cartridge required two blows of the firing-pin to set it off.

VII.—EXCESSIVE CHARGES.

Eighty-five grains powder and 1 bullet. Worked all right.
Ninety grains powder and 1 bullet. Worked all right.
Ninety grains powder and 2 bullets. Worked all right.
Opened hard, but still effective; extracted the shell all right.

REMINGTON-KEENE GUN, No. 27.

DESCRIPTION.

This is the gun which was afterwards slightly modified, re-entered, tested, drawn, and described as No. 30 (Plate XIV).

SYNOPSIS OF TESTS.

The gun was presented by Mr. Whipple (representing the Messrs. E. Remington & Sons), who fired it in the safety test, ten shots in 29 seconds. Two misfires.

Regular tests.

I.—RAPIDITY WITH ACCURACY.

Twenty-seven shots were fired, leaving 2 in the magazine, and making 17 hits.

Same as single shooter.

Thirty-two shots were fired, making 24 hits.

The gun worked very hard, opening and extracting the shell with great difficulty, and was withdrawn for modification.

MARLIN GUN, No. 28.

(Plate XIII.)

DESCRIPTION.

This was the same gun described and tested as No. 16, it having been withdrawn for repairs.

SYNOPSIS OF TESTS.

The gun was handled in the safety test by Mr. J. J. Sweeney (representing the Marlin Fire-Arms Company, of New Haven, Conn.), who fired the ten shots in 8 seconds.

Regular tests.

I.—RAPIDITY WITH ACCURACY.

Thirty-six shots were fired, leaving 8 in the magazine, making 25 hits.

Same as a single shooter.

Thirty-six shots were fired, making 21 hits.

At the thirty-fourth shot the stock-tip broke off, caused by jarring forward of the forestock and magazine, the stud securing it to the barrel in front becoming unsoldered. And at this point the tests were suspended for repairs.

II.—RAPIDITY AT WILL.

Twenty-five shots were fired.

Same as a single shooter.

Twenty-three shots were fired, the gun working well.

III.—ENDURANCE.

Five hundred shots were fired, gun working well through the test.

IV.—DEFECTIVE CARTRIDGES.

No. 1. Very slight escape of gas above and below.
No. 2. Same as No. 1.
No. 3. No escape perceptible.

V.—DUST.

Dust seemed to have little or no effect on the gun, which worked as easily at the close as before being subjected to the foregoing tests.

VI.—RUST.

Gun very thoroughly rusted, and opened with some difficulty.

VII.—EXCESSIVE CHARGES.

Eighty-five grains powder and 1 bullet. Failed to extract the shell, which was driven out from the muzzle.

Ninety grains powder and 1 bullet. Opened hard.

Ninety grains powder and 2 bullets. Opened with great difficulty; finally effected after long continued effort, and with use of leaden mallet, when it was found the head was off the shell.

SUPPLEMENTARY TESTS.

I.—DEFECTIVE CARTRIDGES.

No. 1. Large escape of gas, blowing open the magazine feed-gate.
No. 2. About the same escape of gas.

First dusting.

Gun worked all right.

Second dusting.

Failed to extract twice, and failed to eject twice.

II.—EXCESSIVE CHARGES.

First. Head of shell blown off and piece of shell lodged under the extractor; opened hard.

Second, third, fourth, and fifth. Heads of shells blown off, and opened about the same.

Cartridges in the magazine found to be discolored and the bullets of those nearest the receiver flattened and bruised at the points.

III.

The usual motions for working a lever gun. Sometimes working a little hard with the folded-head cartridges.

IV.

It being impracticable to work this gun to advantage in the fixed rest, the test, A, was omitted.

Frankford ammunition.

B.—One hundred shots (magazine partly filled, &c.).

Cartridges nearest the chamber showed some discoloration from escape of gas; bullets somewhat flattened at the points, while all were heated and lubricants melted.

C.—One hundred shots (magazine entirely filled, &c.).

Same effects produced as in B, but more marked; one failure to extract shell.

U. M. C. ammunition.

B.—One hundred shots fired. Same remarks.

Three misfires and one failure to extract the shell.

C.—One hundred shots fired. Same remarks.

Two misfires and one failure to extract the shell.

Winchester ammunition.

B.—One hundred shots fired. About the same as before.

Two misfires and one failure to extract the shell.

C.—One hundred shots fired. Same remarks.

Two misfires.

Lowell ammunition.

B.—One hundred shots fired. Same as before.

C.—Fifty-two shots fired.

First 50 shots, six failures to extract shell. Extractor-screw found to have worked loose, and was screwed up.

Second 50. At the second shot, after renewing the cartridges in the magazine, the third cartridge from the chamber exploded in the magazine. Doubtless due to the effects of the recoil on an over-sensitive cartridge.

REMINGTON-KEENE GUN, NO. 29.

DESCRIPTION.

This is the same gun as No. 27, and afterwards drawn and described as No. 30 (Plate XIV).

SYNOPSIS OF TESTS.

The gun was handled in the safety test by Mr. Whipple, who fired the ten shots in seventeen seconds.

Regular tests.

RAPIDITY WITH ACCURACY.

Twenty-nine shots were fired, leaving 6 in the magazine, making 19 hits—1 misfire.

Same as single shooter.

Thirty-four shots were fired, making 21 hits.

Gun opened and worked hard towards the close of the test, requiring several blows with the hand. On inspection the carrier-latch magazine-stop was found to be broken, and the tests were suspended for repairs.

The gun was afterwards withdrawn for modification.

REMINGTON-KEENE MAGAZINE GUN, NO. 30.

(Plate XIV.)

DESCRIPTION.

This gun differs from No. 8 in the following particulars:

The form of the carrier and ejector has been changed; the carrier catch and spring and the magazine cut-off have been omitted and a sliding cartridge-stop, A, Fig. 2, added.

The principle of operation of the ejector and carrier has not been changed.

To the latter a stop-spring, B, Fig. 1, has been added which serves to prevent the escape of cartridges from the magazine, when the carrier is raised, by projecting partly across its mouth.

When the bolt is closed the carrier descends, the stop-spring passes below the mouth of the magazine, and the first cartridge enters the carrier until checked by the sliding-stop, A, as in Fig. 2.

When the bolt is drawn back the sliding-stop is carried with it and the cartridge completely enters the carrier.

The object of the sliding-stop is to diminish the blow of the first cartridge against the carrier when forced its full length by the pressure of the magazine spring.

SYNOPSIS OF TESTS.

The gun was handled in the safety test by Mr. Whipple, who fired the 10 shots in 24 seconds.

Regular tests.

I.—RAPIDITY WITH ACCURACY.

Thirty-six shots were fired, making 29 hits.

As a single shooter.

Forty-one shots were fired, making 8 hits.

II.—RAPIDITY AT WILL.

Twenty-two shots were fired.

As a single shooter.

Twenty-seven shots were fired—one shot lost by false motion of the operator.

III.—ENDURANCE.

Gun worked well and without hitch of any kind through this test.

IV.—DEFECTIVE CARTRIDGES.

No. 1. Large escape of gas through gas-port, and to the rear, over bolt and below.
No. 2. About the same as above.
No. 3. Very slight escape of gas.

V.—DUST.

Gun opened easily and worked well.

VI.—RUST.

Gun thoroughly rusted. Opened and worked without difficulty.

VII.—EXCESSIVE CHARGES.

Eighty-five grains powder and 1 bullet. Gun opened and shell extracted all right.

Ninety grains powder and 2 bullets. Gun opened with difficulty, when it was found that the head of the shell had been blown off and the extractor broken.

By consent of the Board the extractor was replaced by a new one and the position of the gas-port changed from the top of the receiver to one side.

SUPPLEMENTARY TESTS.

I.—DEFECTIVE CARTRIDGES.

Gun worked well.

II.—EXCESSIVE CHARGES.

First. Head of shell burst, opened hard, but extracted all right. Stock split under the receiver, due to resistance to the recoil in the rest.

Second. Head of shell blown off; failed to extract.

Third. Head of shell burst, but extracted all right. Large escape of gas, blackening the cartridge underneath on the carriage.

Fourth. Head of shell burst, gun opened with difficulty, but extracted all right; large escape of gas.

Fifth. Head of shell blown off; opened with much difficulty. Cartridges in the magazine found to be much blackened by the escape of gas, and the bullets bruised at the points.

On examination the gun was found to be much fouled and the receiver sprung.

III.—FRANKFORD AMMUNITION.

A.—Seventeen shots were fired, the last shot being solid head.

Heads of shells much swollen; gun opened with great difficulty, and failed to extract last shell.

The receiver was sprung, and the bearing of the bolt, when closed, found to be so much battered as to disable the gun, and the tests were discontinued.

SPENCER-LEE GUN, NO. 31.

DESCRIPTION.

This was the same gun afterwards drawn and described as No. 35 (Plate XVII), having been withdrawn for repairs and slight modification.

SYNOPSIS OF TESTS.

The gun was handled in the safety test by Mr. Spencer, who fired the ten shots, using two magazines, in 18 seconds.

Seventh shot the gun failed to eject the shell, causing some delay.

Second trial, ten shots were fired in 9½ seconds.

Regular tests.

The gun was handled in these tests by Mr. Spencer, one of the inventors.

I.—RAPIDITY WITH ACCURACY.

Using a number of magazines, 63 shots were fired, making 61 hits.

As a single shooter.

Thirty-seven shots were fired, making 26 hits.

II.—RAPIDITY AT WILL.

Forty shots were fired.

As a single shooter.

Twenty shots were fired.

In this test several failures to eject were observed, and it was thought due to want of power in a certain spring; in the effort to correct which the spring was broken and the trial was suspended for repairs.

MAY 18, 1882.

The tests were resumed from the first regular test, the gun being handled by Mr. Hare, expert for the Board.

I.—RAPIDITY WITH ACCURACY.

After 24 shots and two cartridges being passed through the receiver without firing, due to faulty manipulation on the part of the operator, and some delay being caused by a failure to drive the magazine home in inserting, a second trial was decided upon.

Second trial.—Four cartridges failed to feed up properly from the magazine, and were jammed vertically in the receiver, causing delay.

Third trial.—Firing-pin broke in this trial, and the gun was withdrawn for repairs and modification.

DEAN GUN, No. 32.

DESCRIPTION.

This was a similar gun to Nos. 22 (Plate XI), 23, and 25, slightly modified.

SYNOPSIS OF TESTS.

The gun was handled in the safety test by the inventor, who fired the 10 shots in 13 seconds.

A slight hitch was observed in working, caused by imperfect ejection of the empty shell.

Regular tests.

I.—RAPIDITY WITH ACCURACY.

First trial.—Failed through faulty manipulation on the part of the operator after firing 10 shots.

Second trial.—Gun worked very hard, and after firing six shots the front magazine opened and the working of the gun was stopped by the meeting of two cartridges on the carrier.

Third trial.—Seventeen shots were fired (magazines emptied), making ten hits, and eleven cartridges replaced in the time allowed (two minutes).

As a single shooter.

Twenty-three shots were fired, making 21 hits.

Gun worked very hard in these tests, injuring the hand of the operator, failing to eject the empty shell four times, and requiring the muzzle to be rested on the table in order to operate the lever.

II.—RAPIDITY AT WILL.

Magazines emptied (17 shots) and five cartridges replaced in the time allowed (one minute).

Same remarks as to the working of the gun as before.

As a single shooter.

Ten shots were fired, gun working very hard as before.

The inventor was here informed that in the opinion of the Board the gun worked too hard, and required too much time and manipulation for refilling the magazine for military purposes, and it was accordingly withdrawn for the purpose of correcting these defects.

CHAFFEE-REECE MAGAZINE GUN, No. 33.

(Plate XV.)

DESCRIPTION.

This gun does not differ in principle from No. 6, already described. The cut-off to the magazine, however, has been materially altered as may be seen in detail, in Figs. 3, 25, 26, 27, 29, and 30.

The bar, Fig. 26, is screwed to the side of the receiver, which is cut away as in Figs. 3 and 25, forming between it and the receiver a slot in which that arm of the extractor which is connected with the magazine system slides. The upper edge of the bar has a lip, A, which turns over the stock on that side.

On the inner side of the bar are two grooves, B and C, in the former of which a tenon, D, of the cut-off slide, Fig. 30, has a reciprocating motion when the piece is used as a single loader, and in the latter when used as a magazine gun.

If this tenon be pressed forward, as it will be when the bolt is closed, until it enters the recess F, of the cut-off, Fig. 29, it may be transferred from one groove to the other by rotating the cut-off about its pivot, G.

The arm H, Fig. 9, of the extractor enters the groove E, of the slide, Fig. 30; consequently, motion of the bolt produces a corresponding motion of the slide. A tenon, I, on the link connected with the sliding magazine bar, Fig. 20, enters the recess K, Fig. 9, of the arm of the extractor; when the cut-off slide is at its lowest point, the side of its groove crosses the recess in the extractor-arm. The tenon of the link cannot then escape from the recess, and consequently must move when the bolt is moved, thus operating the sliding bar of the magazine.

If the tenon of the slide be transferred to the groove B, Fig. 26, the tenon of the link will no longer be held in the recess in the extractor-arm; the latter will move away from the tenon, and the piece can then only be operated as a single loader.

Slight changes have been made in the form of the ratchet-bars of the magazine, in the notches for the heads of the cartridges, in the springs, Figs. 18 and 19, which hold the bars in position, and in the general finish of the piece.

SYNOPSIS OF TESTS.

The gun was handled in the safety test by Mr. Chaffee, who fired the 10 shots in 17 seconds.

Regular tests.

I.—RAPIDITY WITH ACCURACY.

First trial.—Failed on account of cartridge being first placed in the chamber before the magazine was filled.

Second trial.—Thirty-eight shots were fired, making 25 hits and leaving 1 in the magazine.

Same as a single shooter.

Forty-one shots were fired, making 15 hits.

II.—RAPIDITY AT WILL.

Twenty-three shots were fired, leaving 7 in the magazine (full).

As a single shooter.

Twenty-six shots were fired.

III.—ENDURANCE.

Gun worked well throughout this test, and was in good order at the close.

IV.—DEFECTIVE CARTRIDGES.

No. 1. Very liberal escape of gas from port, on top and from under the bolt along the side.

No. 2. Liberal escape of gas through the ports and over the top of the bolt-head.

No. 3. Slight escape of gas.

V.—DUST.

But little affected in its working in this test.

VI.—RUST.

Gun thoroughly rusted. Opened with great difficulty and worked very hard throughout—this test requiring constant use of the mallet.

VII.—EXCESSIVE CHARGES.

Eighty-five grains powder and 1 bullet. Extracted the shell; gun working about as before.

Ninety grains powder and 1 bullet. Extracted the shell; gun working about as before.

Ninety grains powder and 2 bullets. Extracted the shell; gun working about the same.

On taking the gun apart after the foregoing tests it was found to be in working order.

SUPPLEMENTARY TESTS.

I.—DEFECTIVE CARTRIDGES.

Gun worked well.

II.—EXCESSIVE CHARGES.

Some difficulty encountered in loading the magazine, partly due to dust in the tube from the last test.

Bullets of the second and third cartridges in the magazine slightly flattened at the points, evidently from contact with the bases of cartridges in front due to the excessive recoil and looseness of the parts.

Gun opened and extracted all right.

III.

The usual motions required for working a bolt-gun with the handle in the middle.

IV.

Lowell ammunition.

A.—One hundred shots fired.

Some of the bullets of the cartridges in the magazine slightly bruised and flattened, the second from the receiver always to the greatest extent.

Winchester ammunition.

A.—One hundred shots fired. Same remark; the second bullet from the receiver showing greatest amount of flattening.

U. M. C. ammunition.

A.—One hundred shots fired. Same remarks.

Frankford ammunition.

A.—One hundred shots fired, 70–500; 70–405 in the magazine. Same remarks.

Lowell ammunition.

C.—One hundred shots fired.

Winchester ammunition.

C.—One hundred shots fired.

Bullet of last cartridge in magazine slightly bruised. (No. 7.)

U. M. C. ammunition.

C.—One hundred shots fired. Same remarks.

Frankford ammunition.

C.—One hundred shots fired, 70–500; 70–405 in the magazine. Same remarks.

HOTCHKISS MAGAZINE GUN, NO. 34.

(Plate XVI.)

DESCRIPTION.

This gun, while retaining the general features of the Hotchkiss system, differs in so many of its details from Nos. 4, 5, and 9, as to require special mention.

The stock is made in two parts, the tip and the butt; the magazine being in the latter.

The receiver on its exterior is of the form usually adopted for jointed-stocked guns.

A little in advance of the middle of the receiver is a shoulder which has been recessed for a tenon on the rear end of the tip-stock for the purpose of preventing spreading of the latter at that point.

The movement of the tip-stock to the front is prevented by a lug, A, Figs. 1 and 2, Plate XVI, which enters a corresponding recess in the stock. This lug is held securely by the front guard-screw which passes through its rear. The butt-stock is held rigid with the receiver by the tang and guard screws, and also by a combination of the guards and magazine-tube as explained later on.

The tang is solid with the receiver, and the guard is practically made so by being screwed to the receiver both in front and rear.

The rear of the receiver is concave, and the front end of the butt-stock is of a corresponding convexity. This, in connection with the tang and guard which extend considerably to the rear of the receiver, secures the stock against any vertical movement.

The tang-screw enters a washer or nut, B, Fig. 1, let in the stock above the magazine-tube, through an opening underneath the guard.

At the front end of the magazine-tube, Fig. 15, is a projection, L, which, entering a slot on the interior of the receiver, prevents rotation of the tube. A shoulder, C, Figs. 1 and 2, on the inner surface of the guard, bears against the rear of this projection and prevents the tube from being withdrawn.

On the rear end of the tube is a screw-thread for the nut D, which bears against a shoulder centerbored in the stock. When the nut is screwed clear on, the stock is drawn tightly against the rear of the receiver. The outer surface of the nut is slotted for the blade of a screw-driver.

The breech-bolt is composed of three parts, viz, the body, or locking tube, Fig. 5, of which the handle forms a part; the bolt-head, Fig. 6; and the cocking piece or hammer, Fig. 4, to which the firing-pin is secured by a screw thread. A small screw at right angles to the axis of the firing-pin prevents its becoming unscrewed. The body of the bolt is hollowed out for the firing-pin and spring; the latter bears on a shoulder near the rear end of the body.

The bolt-head, which supports the cartridge, at the instant of fire carries the extractor, Fig. 7, which is attached to its side by means of a dovetail tenon. On the bolt-head is a projection, B′, which, turning in a groove, C′, in the body of the bolt, serves to hold the two parts together. The cocking-piece is held in contact with the body of the bolt by the tension of the firing-pin spring. The firing-pin, Fig. 8, is flattened near its front ends. The bolt-head is prevented from turning about the pin, when the bolt is withdrawn, by the tenon on the extractor which extends into the firing-pin hole nearly to the flattened surface of the pin. A projection, D, Figs. 1 and 6, on the bolt-head enters a corresponding recess, N, Fig. 1, in the receiver when the bolt is locked; consequently the bolt-head cannot turn when the body of the bolt is rotated about its axis as in the act of locking the piece.

The cocking-piece is shown in Fig. 4. A projection, E, fits in a recess, F, on the rear of the body of the bolt. The form of this projection, and of its corresponding recess, is such that when the bolt is unlocked the cocking-piece is *cammed* back beyond the nose of the sear, or upper extremity of the trigger, withdrawing the point of the firing-pin within the face of the bolt-head.

When the bolt is locked, which is done by turning down its handle in the cut in the receiver, the firing-pin spring is compressed. By pressing on the trigger the sear is drawn from the cocking-piece, and the firing-pin, driven forward by its spring, explodes the cartridge.

The receiver, shown in Figs. 1 and 2, is cut through at the rear for the reception of the bolt; it is also cut away at the side for the reception of the handle when the bolt is locked.

The form of the side cut in the receiver at its rear is such that the breech-bolt is cammed forward as it is turned to the locking position, forcing the cartridge into the chamber. As the firing-pin cannot reach the cartridge until the bolt is locked, accidental explosions are avoided.

The shape of the cut at front is such as to cam back the bolt during the unlocking, starting the empty shell. The shells are thrown out that side of the receiver which is cut away.

The extractor being on the same side, the shells are unsupported against its side-pull the instant they leave the chamber. Their front ends being constantly deflected from the axes of the receiver, the shells fall to the ground.

The magazine is in the butt-stock. A hole is drilled in the receiver at its near end, below the breech-bolt, oblique to the axis of the bore, Fig. 1. Through this hole the cartridges are fed from the magazine into the receiver, when the bolt forces them into the chamber.

The trigger shown in Fig. 9 bends around the magazine tube.

The sear-spring E′, Figs. 1 and 2, bears on its under front surface in the usual manner, rotating it upward about its pivot, F′.

The sear-spring is terminated at its rear by a cartridge detent, G, which projects through a small opening in the magazine tube.

When the magazine is filled, which is done by pressing the cartridges into it from the receiver, the front cartridge bears against the detent, as seen in Fig. 1. By pressing on the trigger the detent is depressed below the level of the magazine, and the first cartridge, under the pressure of the magazine spring, slips by and bears against the under side of the bolt.

When the trigger is pulled, which can only be done when the bolt is closed—since an arm, H, Fig. 1, comes in contact with the under side of the bolt, as seen in the figure—the first cartridge passes the detent, and is checked by the under surface of the bolt itself.

When the bolt is drawn back, this cartridge, under the impulse of the magazine-spring, is shot into the chamber, while another one moves up against the detent.

When the trigger is pulled to fire the first cartridge, the second one passes the detent, and is in turn checked by the under surface of the bolt. When the bolt is withdrawn with the empty shell, the second cartridge is shot into the chamber, and so on.

The magazine cut-off, Fig. 10, is attached to the left side of the piece. Its shaft, A″, passes through the receiver into the magazine-tube.

When its lever, C″, is parallel with the axis of the piece, the curved side, B″, of the shaft coincides with the upper surface of the magazine-tube, and cartridges can readily pass by it, and the piece is for the time a magazine gun. If the lever be inclined upwards the inner end of the shaft partly crosses the tube and cuts off the escape of cartridges, and the piece may then be used as a single-loader. The cut-off is held in either of its positions by a spring, J, Figs. 1 and 13.

The bolt is locked at full cock when the piece is carried loaded.

The bolt-lock is shown in Fig. 11. Its attachment and method of operation are similar to those of the magazine cut-off.

When the lever O is in line with the axis of the piece, the shaft P passes freely through the slot B, Fig. 9, in the trigger, and the latter is free to move. When inclined upwards the shaft bears under the front side, A, of the slot and prevents the descent of the trigger.

When the trigger is held in its highest position, the part Q enters a groove, A′, on the body of the bolt and thus prevents rotation of the latter, or simply locks it.

This gun carries five cartridges in the magazine and one in the chamber.

As a magazine gun three motions are necessary to operate it, viz, opened, closed, fired. As a single loader four motions are necessary, viz, opened, loaded, closed, fired.

SYNOPSIS OF TESTS.

The gun was handled in the safety test by Mr. Albee, who fired the 10 shots in 17½ seconds.

Regular tests.

I.—RAPIDITY WITH ACCURACY.

Thirty-one shots were fired, making 14 hits, and leaving the magazine full (5 cartridges).

Same as a single shooter.

Forty-five shots were fired, making 21 hits.

II.—RAPIDITY AT WILL.

Twenty-three shots were fired.

Same as a single shooter.

Thirty-one shots were fired.

III.—ENDURANCE.

Five hundred shots were fired, at the close of which it was observed that the butt-stock connection was somewhat weakened and loose.

IV.—DEFECTIVE CARTRIDGES.

No. 1. Liberal escape of gas through ports and over head of the bolt.
No. 2. About the same.
No. 3. Slight escape through gas ports.

V.—DUST.

Gun but little affected by this test.

VI.—RUST.

Gun thoroughly rusted.

Opened with much difficulty, requiring use of a stick as a mallet, and water being applied, after which the bolt moved easily.

Extractor broken in opening the gun, and an examination showed that rust had penetrated a small crack.

Sear-spring failed to operate, and gun had to be taken apart to ascertain cause of trouble, which was found to be due to rust.

Being reassembled, extractor replaced, &c., the gun fired the 20 shots all right.

VII.—EXCESSIVE CHARGES.

Eighty-five grains powder and 1 bullet. Extracted all right.

Ninety grains powder and 1 bullet. Extracted all right.

Ninety grains powder and 2 bullets.

Failed to extract; part of the shell blown through the extractor slot; shell driven out with the rammer.

SUPPLEMENTARY TESTS.

I.—DEFECTIVE CARTRIDGES.

Gun worked well.

First dusting.

Dusted on the full-cock, there being no half-cock notch. Gun worked well.

Second dusting.

One failure to extract first shot.

II.—EXCESSIVE CHARGES.

Gun worked well. The bullets of cartridges in the magazine but little flattened at the points.

III.

The usual motions for working a bolt with handle in the middle.

IV.

Lowell ammunition.

A.—One hundred shots fired.

Bullets of the cartridges in the magazine much flattened at the points, and primers showing contact with the lead.

Winchester ammunition.

A.—One hundred shots fired. Same remarks.

U. M. C. ammunition.

A.—One hundred shots fired. Same remarks.

Frankford ammunition.

A.—One hundred shots fired. Same remarks.

Lowell ammunition.

B.—One hundred shots fired.
Bullets but slightly flattened at the points in this test.

Winchester ammunition.

B.—One hundred shots fired. Same remarks.

U. M. C. ammunition.

B.—One hundred shots fired. Same remarks.

The Board here decided to abandon the test of the partly-filled magazine with this gun, as being less likely to produce accidental explosions in the magazine than the one preceding.

Lowell ammunition.

C.—One hundred shots fired.
Bullets flattened at points about as in A.

U. M. C. ammunition.

C.—One hundred shots fired. Same remarks.

Winchester ammunition.

C.—One hundred shots fired. Same remarks.

SPENCER-LEE GUN, No. 35.

(Plate XVII.)

DESCRIPTION.

This gun is shown in section, breech opened and closed, and largely in detail in the plate.

The breech-block A, Figs. 1 and 2, is supported against the pressure of the gas, when the piece is fired, by the recoil-block B, solid with the guard, which has a circular recess concentric with the rear of the breech-block. The latter is slipped in the recess sideways and has, when assembled, a motion of rotation in a vertical plane. The recoil-block is in turn supported by the rear of the receiver, as seen in Figs. 1 and 2.

The trigger C, Fig. 21, and hammer D, Fig. 17, are pivoted in the guard-plate, the nose of the former or the sear being held in position in the notch of the latter by the sear-spring E, Figs. 1, 2, and 3.

The main-spring F is connected with the hammer and the under rear of the breech-block by the swivels G and H, Figs. 1 and 2.

The piece is shown cocked in Fig. 2, the firing-pin being seen at J.

When the trigger is pulled the head of the firing-pin is struck by the upper end, K, of the hammer.

The breech-block is operated by a cam-pin, C′, Fig. 1, with friction roller on the inside of the rear end on the left of two sliding bars, L.

connected by the hand-grasp M, Fig. 2. The cam-pin travels in a groove on the left side of the breech-block. The groove has a frog or switch, N, Figs, 3 and 11, pivoted near its rear. When the cam-pin enters the groove, as it does when the forked slide is forced to the rear, it rolls over the incline O of the frog.

The pin cannot rise, since the bars of the slide travel in grooves on the inside of the receiver. Hence the frog must be pressed downward, and its point in turn pressing on the bottom of the groove in the block compels the latter to descend.

When the pin passes out of the groove to the rear, the front of the breech-block would rise above the receiver under the pressure of the mainspring, if not held down by the extractor, as explained later on.

When the slide is returned to its first position, the cam-pin travels on the lower side of the groove, the frog turning freely about its pivot, and the front of the block is forced to descend to the level of the chamber.

The extractor, Fig. 7, is pivoted in the slot P, Fig. 2, in the right branch of the slide, as seen at Q, Fig. 4. When the slide is carried to the rear, the free end of the extractor passes on the inside of the receiver in the groove in which the slide works, and its hook, R, pushes the shell to the rear. Before, however, the extractor reaches the shell, the block will have begun to fall, and the lever S of the shell starter, Figs. 1, 2, and 9, being struck by the right branch of the slide, will have so loosened the shell that the extractor has merely to push it out of the chamber into the upper surface of the block. When the extractor has passed beyond the shoulder T, Fig. 4, in its rearward motion, the breech-block, under the pressure of the mainspring, will fly up and eject the empty shell. If the block be operated quickly the shell will be ejected by riding up the incline at its rear.

The piece is cocked in the act of opening the breech-block by the cam-pin coming in contact with the hammer and pressing it back until the nose of the sear enters the notch. At the front of the breech-block is a movable face or head, U, Figs. 1, 2, and 12, which is forced against the base of the cartridge during the closing of the breech. On the opening of the latter the head drops away, and thus facilitates extraction of the shells. The head is operated by the shaft V, Figs. 1, 2, and 3. The shaft is in turn operated by the cam-pin, in its passage through the groove coming in contact with its arm or lever, W, Figs. 3 and 19.

When the pin first enters the groove it strikes on the face X of the lever and rotates the shaft until its flat side is parallel to the face of the block, Fig. 3. The head can then drop back against the body of the block, as in Fig. 1. When the cam-pin is returned to its first position it travels the lower part of the groove, raises the frog, and strikes against the face Y of the lever W, and rotates the shaft to the position shown in Fig. 2, its edge forcing the face of the block against the cartridge.

A device for locking the hammer until the breech-block is closed is shown in Fig. 16, and at Z, Fig. 3. It is interposed between the head of the hammer and a shoulder, D′, on the shaft V. The closing of the breech-block rotates the shaft and withdraws the shoulder from the front of the locking-bar.

The latter is then free to move to the front to the extent permitted by the recess in which the tenon on the bar enters, and the hammer can fall if the trigger be pulled.

The cartridges, when the piece is used as a magazine gun or single-loader, are drawn forward into the chamber of the arm A, of the extractor.

The magazine is that known as the Lee, with very slight modification. It is attached to the under side of the breech-block, and rises and falls with it. The breech-block is recessed on its under side sufficiently to receive a single cartridge. When this one is drawn forward into the chamber another from the magazine takes its place in the block. It will be seen then that the complete backward motion of the slide causes the block to descend, the shell to be pushed out on its upper surface, and then the block to fly up and eject the empty shell; the forward motion then carries a cartridge from the magazine into the chamber and causes the block to descend to its proper position in rear of it.

A cut-off, Fig. 24, may be so turned as at B′, Fig. 3, to limit the backward motion of the slide, thus preventing the extractor passing beyond the shoulder T. The block then cannot rise and bring the cartridges from the magazine opposite the chamber. The piece may consequently be used as a single loader. If the cut-off be turned vertically downward, the piece may be used as a magazine gun. If turned upward to its farthest extent, a small pin, E′, Figs. 3 and 24, on its under side will enter a notch in the slide and lock it, and therefore the breech-block.

Three motions are necessary to operate this piece as a magazine gun, viz, the movement of the slide to the rear, to the front, and the pulling of the trigger. In addition, when used as a single loader, loading.

SYNOPSIS OF TESTS.

The gun was handled in the safety test by one of the inventors (Mr. Spencer), who fired the 10 shots in 9 seconds, using two magazines.

Regular tests.

I.—RAPIDITY WITH ACCURACY.

First trial.—By R. T. Hare, expert for the Board.

Thirty-seven shots were fired, making 35 hits, some time being lost by the operator failing in the first instance to make the full motion in bringing back the slide.

Second trial.—By Mr. Spencer.

Sixty-nine shots were fired making 66 hits, leaving the magazine full (5 shots) and attached; 1 misfire.

As a single shooter.

By R. T. Hare, 38 shots were fired, making 34 hits.

II.—RAPIDITY AT WILL.

Twenty-seven shots were fired; one passed through without firing, the operator failing to pull the trigger; 3 cartridges were left in the magazine.

As a single shooter.

Twenty-six shots were fired.

III.—ENDURANCE.

Five hundred shots were fired, the gun working well throughout; the sixth 50 shots being fired in 1 minute and 15 seconds.

IV.—DEFECTIVE CARTRIDGES.

No. 1. Slight escape of gas; shell extracted easily.
No. 2. About the same.
No. 3. Very slight escape of gas, and extracted about the same.

V.—DUST.

Gun seemed but little affected by this test.

VI.—RUST.

Gun thoroughly rusted and dry. Opened hard, requiring use of the lead mallet and force applied in various directions. After opening, water was poured into the breech mechanism to facilitate working by hand.

After firing a few shots the breech-block was taken out to ascertain the cause of a difficulty encountered in closing, sometimes requiring a slight return motion of the slide. This was found to be due to an accumulation of rust between the receiver and slide, springing the latter towards the breech-block and causing the end of the friction roller to engage a sharp corner of a slot in the block, and which it did not readily pass. This being slightly rounded off, as should have been done in finishing, the 20 shots were fired without difficulty, the gun working somewhat stiffly.

VII.—EXCESSIVE CHARGES.

Eighty-five grains powder and 1 bullet. Opened and extracted all right.

Ninety grains powder and 1 bullet. About the same as before.

Ninety grains powder and 2 bullets. About the same as before, though the head of the shell was considerably bulged out; the head of the breech-block not fitting as tightly as it was thought it might be readily made to do.

SUPPLEMENTARY TESTS.

I.—DEFECTIVE CARTRIDGES.

Gun worked well.

First dusting.

First defective; missed fire first trial.

Second dusting.

Gun worked all right.

II.—EXCESSIVE CHARGES.

Gun worked well. Heads of shells somewhat swollen, due to yielding of breech-block head.

III.

Easy and rapid.

IV.

Lowell ammunition in the magazine (70–405), using 70–500 Frankford for firing.

A.—One hundred shots fired in the iron rest. One misfire.

Breech-block dropped down, partly opening the gun after each shot, due to the return movement of the recoil-spring acting against the weight of the hand-piece, &c., when not supported in the hand.

Bullets of the cartridges in the magazine slightly bruised.

C.—Fifty shots fired. Same remarks.

Test discontinued, the Board being satisfied from the effects produced on cartridges in the magazine that the liability to accidental explosion was reduced to a minimum in this system of detachable magazines.

LEE MAGAZINE GUN, No. 36.

(Plate XVIII.)

DESCRIPTION.

This gun differs from No. 10 only in the position and shape of the bolt-handle and in the form of its magazine. The handle has been cut from the body of the bolt, leaving the locking-shoulder A, and transferred to the rear, as shown in Figs. 1 and 6. It has also been bent down closely to the stock, the ball, with which it is terminated, alone projecting outward and upward. The object of this change was to enable one to reach the trigger without entirely removing the hand from the bolt.

The front face of the magazine, Figs. 1 and 16, has been made plain, the spring-catch B having been found sufficient to retain the magazine in place. To prevent the cartridges being jarred from the magazine a strong spring, C, Fig. 1, has been placed in a vertical groove in its side.

The spring has a sliding motion in the groove, being operated by the button or head D, Figs. 1 and 16, the arm of which passes through an elongated opening in the side of the magazine, and is riveted to the spring.

The upper end of the spring is curved so as to bear on the top cartridge, and thus hold it and those below it in place.

When the magazine is applied to the gun, the button on the spring comes into contact with the under side of the receiver, and is pressed downward, withdrawing the upper end of the spring to a point opposite the groove in the side of the magazine, into which it springs, and the cartridges are free to enter the receiver, the piece then being a magazine gun.

SYNOPSIS OF TESTS.

The gun was presented and handled in the safety tests by Mr. Lee, the inventor, who fired the 10 shots in 9 seconds.

Regular tests.

I.—RAPIDITY WITH ACCURACY.

First trial.—By R. T. Hare. Forty-one shots were fired, making 27 hits, and leaving 4 in the magazine.

Second trial.—By Mr. Lee. Sixty-eight shots were fired, making 41 hits, and leaving 3 in the magazine.

As a single shooter.

Forty-six shots were fired, making 31 hits.

II.—RAPIDITY AT WILL.

Thirty-five shots were fired.

As a single shooter.

Twenty-nine shots were fired.

III.—ENDURANCE.

Five hundred shots were fired, the gun working perfectly throughout; a little hard when overheated by rapid firing. In this test 50 shots were fired by Mr. Lee in one minute.

IV.—DEFECTIVE CARTRIDGES.

No. 1. Liberal escape of gas through the ports.
No. 2. About the same as No. 1.
No. 3. Slight escape.

V.—DUST.

Gun but little affected in its working by this test.

VI.—RUST.

The gun was first rusted by mistake on the full cock, when it was decided to clean it up and repeat the process.

Second rusting.—Gun thoroughly rusted and dry, opened by blows with a stick of wood (tent-pin), and after a few minutes' manipulation, and water being poured on, fired the 20 shots without difficulty.

VII.—EXCESSIVE CHARGES.

No. 1. Opened and extracted all right.
No. 2. About the same.
No. 3. About the same, only requiring to be snapped before opening.

SUPPLEMENTARY TESTS.

I.—DEFECTIVE CARTRIDGES.

First extracted hard; second, easily.

First dusting.

Gun worked well. Piece of the shell at angle of the cross-cuts on head of the first defective blew off and lodged under extractor, causing failure to extract until taken out.

Second dusting.

Gun opened a little stiffly at first, but worked well.

II.—EXCESSIVE CHARGES.

Bullets in magazine slightly bruised at points; contact with the magazine due to the recoil.

III.

The usual motions for working a bolt-gun with handle in the rear of the bolt. The gun not necessarily taken from the shoulder, or hand from the bolt, until magazine is emptied.

IV.

Frankford folded-head (70–405) ammunition in the magazine, 70–500 being fired.

A.—Forty shots were fired.

Magazine dropped out several times during the test, the notch by which it was held by the retaining catch not being deep enough; otherwise worked well.

Cartridges in magazine showed, at the points of the bullets, contact with the front of the magazine. Firing from the magazine, cartridges remaining in the magazine showed a mark for each shot fired.

Gun not readily loaded as a single shooter with the magazine attached, and the test was discontinued, the Board being satisfied that the best results of which this gun was capable were not obtained when used as a single loader *with the magazine attached* and filled.

BURTON, No. 37.

DESCRIPTION.

A drawing of this gun was not made, but it does not differ materially from the well-known Ward-Burton magazine gun described in the report of the Board on magazine guns of 1874, except that this gun has a magazine on the right side and above the receiver, from which the cartridges are fed into the latter by gravity when the bolt is drawn back.

SYNOPSIS OF TESTS.

The gun was presented by Mr. W. A. Burton, who handled it in the safety test by firing the 10 shots in 35 seconds.

One cartridge stuck in the tin feed case placed on the magazine.

On inspection it was found that the chamber was too large for the regulation cartridge, the shells swelling out to such an extent as to loosen the anvils, permitting them to drop out.

It was thought unsafe to continue tests, and they were suspended to correct this difficulty.

On resuming the tests four weeks later, on the 14th of August, the same defect was still found to exist, and the Board being unable to give the representation any further time, the tests were abandoned.

BURTON, No. 38.

DESCRIPTION.

This gun differs from No. 37, presented by the same gentleman, in having the magazine under the barrel instead of on the receiver.

A drawing of this gun was not made, but it does not differ materially from that of the same name submitted to the Board on magazine guns of 1878, and it is similar in its main features to several others tested by this Board.

SYNOPSIS OF TESTS.

It was handled in the safety test by Mr. W. A. Burton, who fired a preliminary test, when it was also found to be chambered too large for the regulation cartridge, and the tests were suspended to correct this difficulty.

This gun was never resubmitted to the Board.

THE SPRINGFIELD-JONES MAGAZINE GUN, No. 39.

(Plate XIX.)

DESCRIPTION.

This is the well-known United States service Springfield rifle, with several alterations and the addition of a magazine.

The alterations and additions are as follows:

The firing-pin guard has been removed, and the outer end of the thumb-piece slotted in the direction of the axis of the barrel. This slot receives one end of a lever, A, Fig. 1, which is secured by a pin, I, about which it may turn in a direction toward the under side of the thumb-piece.

A flat spring, K, lying in a groove in the upper surface of the thumb-piece—to which it is secured by a screw, L—bearing on a flat and against a shoulder on the upper extremity of the lever, returns it to position and limits its motion in the reverse direction. An arm, B, Fig. 3, securely attached by the tumbler-screw to the hammer, on which a shoulder has been cut to prevent rotation, bears against the lower end of the lever A and raises the thumb-piece when the hammer is brought to the half or full cock and thus unlocks the breech-block.

A piston, C, Figs. 1 and 5, pivoted to the left side of the breech-block, is surrounded by a spiral spring, the rear end of which finds a bearing on a metal plate attached to the left side of the stock, the front of which is bent at right angles to the receiver. A hole through the plate admits the rear end of the piston. When the breech-block is unlocked by the cocking of the hammer the spiral spring throws up the block and extracts the empty shell.

The well of the receiver has been deepened at the rear, and the lower part of the breech-pin cut away to form a channel through which the cartridges may feed from the magazine, which is in the butt-stock.

The ejector-stud has been replaced by a movable one, D, Figs. 1, 2, and 8, which is depressed to the bottom of the receiver at the instant the cartridge leaves the magazine. This stud is pivoted at its rear to a block just above the trigger-mortise. A short distance in advance of its pivot it passes through a pin, Fig. 9, which bends about the magazine tube and enters the tang-screw hole above. The upper extremity of this pin is provided with a screw-thread which enters the hollow screw E, Figs. 1 and 2.

Just below the hollow-screw, and on the bent pin, is a cartridge detent, Fig. 7, the point F of which passes through an opening in the magazine-tube sufficiently far to prevent the escape of the cartridges by catching on the flange or rim of their heads.

A second detent, N, Figs. 1, 2, and 11, on the under side of the tube, is attached to the arm of the ejector-stud.

A spring, Figs. 1, 2, and 6, attached to the bottom of the guard-plate by the guard-nut, bears on the lower shoulder G of the pin, Fig. 9, and thus holds the detents in position.

The magazine proper consists simply of the familiar tube, spiral spring, and piston, and requires no comment.

The operation of the magazine system is as follows:

The piece having been cocked and the breech-block thrown up by the spiral piston spring, the operator presses on the hollow screw E. The lower detent descends, and the first cartridge, under the pressure of the magazine spring, slips by and enters the chamber.

As the lower detent is depressed the upper one also descends, checking the second cartridge. When the pressure on the hollow screw E is relieved the spring H, Figs. 1 and 2, returns the detents to the original positions; the second cartridge then passes the upper and is checked by the lower detent. As a single-loader the piece is operated in the usual manner, the lower detent serving as a cut-off to the magazine.

As a magazine gun three motions are necessary to operate it, viz, opened, closed, fired.

As a single-loader four motions are necessary, viz, opened, loaded, closed, fired.

This gun carries five cartridges in the magazine and one in the chamber.

SYNOPSIS OF TESTS.

This was a regular Springfield breech-loading rifle converted into a magazine gun by modification. It was presented by Mr. A. Sheridan Jones, of Dakota, the inventor, who handled it in the safety test, firing the ten shots in 45 seconds.

Second trial.—By Mr. R. T. Hare, time 48 seconds.

The ejector-spring found to be too weak to operate automatically and was changed.

Third trial.—By R. T. Hare, time of 10 shots 40 seconds.

The guide on the follower in the magazine came off in the foregoing and the tests were suspended for repairs. The tests were resumed the following day.

REGULAR TESTS.

I.—RAPIDITY WITH ACCURACY.

Seventeen shots were fired, making 16 hits, leaving one cartridge in the magazine.

Two cartridges escaped from the magazine at once, checking the automatic operation of the block until one could be thrown out.

One shell struck against the barrel-screw and fell back into the receiver.

Several failures to eject automatically. The block in such cases had to be operated by hand.

Several cartridges failed to feed into the chamber and had to be pushed in by hand before the breech could be closed.

As a single shooter.

Forty-one shots were fired, making 31 hits, and leaving a cartridge in the chamber. Four failures to eject automatically. Block operated by hand.

II.—RAPIDITY AT WILL.

Eleven shots were fired, leaving 1 cartridge in the magazine. Six failures to eject as before.

As a single shooter.

Twenty-two shots were fired. Nine failures to eject.

III.—ENDURANCE.

Four hundred and eighteen shots were fired.

In the first 200 shots many failures to eject automatically, when the block had to be operated by hand as in the ordinary Springfield rifle.

At this stage the ejector-spring was strengthened by adding another one to it. The same trouble was, however, still found to exist, only in a less degree; about one-half of the shells failing to eject automatically, and about the same proportion failing to feed into the chamber. The hinge of breech-block was here well oiled to facilitate automatic working and ejection of shells, with some good effect; nearly all of the shots following were ejected all right.

At the 418th shot the stock split open through the side screw-holes back to the comb.

It was thought due to the removal of the long screw and cutting away the stock for insertion of magazine-tube, as well as to the resistance to recoil offered by the fixed rest in which it was fixed.

Gun withdrawn.

RUSSELL-LIVERMORE MAGAZINE GUN, No. 40.

DESCRIPTION.

The Russell gun, No. 17 (Plate IX), having been modified as explained below, was re-entered as No. 40.

The trigger has been set farther forward, the object in making this change being to facilitate rapid firing.

Instead of the notch D′, Fig. 2, Plate IX, in the bottom of the receiver, a spring ejector has been introduced.

This spring is screwed at one end to the bottom of the receiver on the outside. The other end of the spring, notched to receive the rim of the empty shell, projects through an opening in the receiver; when the shell is extracted and drawn into the notch of the spring, the latter, being pressed down, reacts and throws out the shell through the opening.

An addition to the magazine, Fig. 9, Plate IX, has been made. This addition consists of a metallic rim, screwed to the top of the magazine, its function being to hold the box from which the magazine is loaded, as explained in the description of No. 17.

SYNOPSIS OF TESTS.

This was the same gun as the Russell, Nos. 14 and 17 (Plate IX), slightly modified and presented by Captain Livermore, U. S. Engineers, who handled it in the safety test, making the 10 shots in 15 seconds.

Regular tests.

I.—RAPIDITY WITH ACCURACY.

Twenty-nine shots were fired, making 28 hits; 4 thrown out in filling, and magazine left full (5 shots).

Second trial.—Twenty-five shots were fired, making 23 hits; 2 cartridges fed up together twice; one case failed to enter the mouth of the magazine and was dropped.

Third trial by Captain Livermore.—Forty-three shots were fired, making 29 hits, leaving 3 in the magazine.

As a single shooter.

Forty-four shots were fired, making 24 hits.

II.—RAPIDITY AT WILL.

By Captain Livermore.—Twenty-seven shots were fired.

Two cartridges were lost out in filling the magazine at one time, and 3 at another.

Second trial.—By R. T. Hare. Fourteen shots were fired; 2 misfires; 2 cartridges fed up together checking the action. In filling, the magazine twice failed to get all the cartridges from the feeding cases; 4 cartridges left in the magazine.

As a single shooter.

Twenty-five shots were fired.

III.—ENDURANCE.

Five hundred shots were fired.

First 50 without feeding cases; the gun worked very well.

Second 50 fired in 2 minutes and 20 seconds.

Third 50 fired in 1 minute and 6 seconds.

Fourth 50 fired in 1 minute and 33 seconds by Captain Livermore, and using the feeding cases. Two misfires due to foul by manipulation; 1 cartridge thrown out of magazine.

Fifth 50, 3 misfires and 1 failure to extract shell.

Eighth 50, 4 misfires.

Ninth 50, 1 misfire.

Tenth 50, 3 misfires.

IV.—DEFECTIVE CARTRIDGES.

No. 1. Liberal escape of gas in all directions.

No. 2. About the same.

No. 3. Small escape of gas.

V.—DUST.

Gun not much affected by this test. One misfire and 1 failure to extract the shell.

VI.—RUST.

Gun thoroughly rusted. Opened with great difficulty, requiring the use of mallet and water; after which could not be made to operate without cleaning up and repairing, and the tests were abandoned.

ELLIOT MAGAZINE GUN.

(Plate XX.)

DESCRIPTION.

This arm is provided with a reciprocating and rotating bolt for closing and locking the cartridge-chamber by means of a handle in the usual way. It is also provided with a double tubular magazine, located in the butt-stock, the tubular chambers being arranged one over the other, and each provided with independent cartridge-propelling devices.

The upper end of revolving pawl *i* is bent inward and works in a longitudinal groove cut in the side of the bolt, as seen in Figs. 3 and 5; and where the bolt is rotated in locking and unlocking the arm it gives a vertical movement to the revolving pawl, which, being actuated by a suitable spring, causes the disk or ratchet *i′* to revolve one notch. On the face of the disk and over each alternate ratchet tooth there is a cam. These cams and the free ends of the double-feed pawl *i″* are so arranged in relation to each other that the cams pass under and raise the ends of the feed pawl alternately. Each time one of the ends of the feed pawl is raised the line of cartridges under it is permitted to move forward until the ball of the first cartridge lodges in the recess between the carrier and bolt. In this position of parts the head of the first cartridge remains a little way in the mouth of the magazine, and the second one has not yet engaged the point of the feed pawl. When the bolt is drawn back after firing, the magazine spring forces the whole column of cartridges forward until the feed pawl engages the head of the second one, and the first one is landed upon the carrier. When the backward movement of the bolt is completed the first cartridge is raised into the receiving chamber by the carrier spring. By this arrangement of parts the shock of arresting the forward movement of the column of cartridges is taken upon the carrier and bolt.

In addition to the ordinary spiral magazine spring there is an auxiliary spring in the bottom of each tubular space, as seen in Fig. 1, the object of which is to cushion the blow of the column of cartridges upon the bottom of the magizine in case of heavy recoil or jolting when the magazine is full or nearly so, and thus prevent accidental explosions. The tubular spaces are provided with projections or shoulders on each side, as seen in Figs. 5 and 7. These projections are so arranged that the cartridge-heads strike them alternately on each side, which causes the heads to vibrate laterally and prevents the cartridges from moving, from any cause, with dangerous rapidity, whereby accidental explosion is avoided. In Fig. 1 it may be seen that the butt-stock and tip-stock are made in separate pieces, being supported at their inner ends by the cheek-pieces *m*, under which they project, as shown in broken lines.

The handle of the bolt is attached to the rear end and has six curves, as follows: Backward and downward, as in Fig. 1 and 2, which carry the handle back within reach of the thumb—while the index finger is on the trigger; also curves downward, outward, and upward, as in Fig. 3, to form a bed for the thumb to rest in. The end of the handle has also a downward curve over the side of the hand.

During the manipulation of the arm the handle is grasped between the thumb and the side of the hand above the index finger, from which it is not at any time released. At the moment of firing the bolt is held in the locked position by the thumb on the handle. In withdrawing the bolt the thumb is bent down a little forward of the lower end of the handle, and the act of returning and locking the bolt carries the index finger back to the trigger and the other three fingers to the wrist of the arm.

Table showing weights, number of cartridges carried, and the comparative performance of all magazine guns before the Board.

REGULAR TESTS.

	Name of gun.	Number of cartridges carried.	Weights.				Safety test.			Rapidity with accuracy.				
			Not loaded.		Fully loaded.					As magazine gun.				
							Time.	Misfires.	Remarks.	Shots.	Hits.	Misfires.	Remained in magazine.	Remarks.
			Lbs.	*Oz.*	*Lbs.*	*Oz.*	"							
1	Remington-Keene	8	10¼	0	11	0	21	......	......	25	18	1	7	Misfire; exploded second trial.
2	Remington-Keene	9	10¼	0	11	1	19	......	......	31	6	......	1	Four thrown out of carrier.
3	Boch	*20	9	0	11	14	......	......	Failed to extract; withdrawn	......	......	......	......	First trial; extractor failed to work and was changed.
4	Hotchkiss	6	8	10	9	1¼	18¼	......	Extractor failed once	31	11	......	......	
5	Hotchkiss	6	9	14	10	7	16½	......	......	25	8	......	2	Magazine twice cut off.
6	Chaffee-Reece	7	10	5	11	0	19	......	......	28	21	......	7	Two failed to feed up from magazine on first trial.
7	Boch	*20	9	0	11	14	34	......	......	18	14	......	2	
8	Remington-Keene	8	9	0	9	12	32	......	Failed to feed up twice	23	21	......	1	Two failures to feed up.
9	Hotchkiss	5	8	8	9	0	14	......	Second trial by "Albee"	32	25	......	1	Magazine once cut off by accidentally striking the ear.
10	Lee	*5	9	0	9	10½	21	......	Using 1 magazine	21	19	......	5	Magazine dropped once.
11	Lee	*5+	9	0	9	10½	12¼	......	do	36	24	......	1	
12	Trabue	7	10	12	11	6	22	......	......	29	25	......	2	Second trial.
13	Boch	9	9	0	9	13½	36	......	Gun worked badly	15	15	......	......	Gun failed to work with any degree of satisfaction; withdrawn.
14	Russell	5	9	8	10	0	23	......	......	31	24	......	......	
15	Boch	9	9	0	9	13½	22	......	......	28	25	......	4	
16	Marlin	9	9	12	10	9½	7	......	......	32	18	......	2	One shot fired before bringing piece to the shoulder.
17	Russell	5	9	8	10	0	26	......	......	30	20	......	1	Misfire; exploded second trial.
18	Boch	9	9	0	9	13½	25	......	......	27	21	......	1	Six cartridges pressed down in receiver before they would enter chamber; third trial, 20 shots.
19	Trabue	7	10	12	11	6	22½	......	......	30	19	......	......	Shells showed distortion by flattening at muzzle.
20	Boch	9	9	0	9	13½	18½	......	......	28	26	......	......	
21	Trabue	6	10	0	10	9	31	......	......	30	19	......	3	Three thrown out in filling the magazine.
22	Dean	17	10	8	12	1	8	......	......	34	9	......	......	Using both magazines.
23	Dean	17	10	8	12	1	8	......	......	34	10	......	......	

Table showing weights, number of cartridges carried, and the comparative performance of all magazine guns before the Board—Continued.

REGULAR TESTS—Continued.

	Name of gun.	Number of cartridges carried.	Weight.				Safety test.			Rapidity with accuracy.				
										As magazine gun.				
			Not loaded.		Fully loaded.		Time.	Misfires.	Remarks.	Shots.	Hits.	Misfires.	Remained in magazine.	Remarks.
			Lbs.	*Oz.*	*Lbs.*	*Oz.*	"							
24	Spencer-Lee	5+	9	8	10	0	11	......	......	64	56	......	......	Second trial by the inventor.
25	Dean	17	10	8	12	1	......	......	At sixth shot receiver bursted, breaking gun in two.	......	......	......	......	
26	Boch	9	9	0	9	13½	12½	......	......	31	25	......	6	
27	Remington-Keene	8	9	0	9	12	29	2	......	27	17	......	2	
28	Marlin.................	9	9	12	10	9½	8	......	......	36	25	......	8	
29	Remington-Keene ...	8	9	0	9	12	17	......	......	29	19	......	6	One misfire.
30	Remington-Keene	8	9	0	9	12	24	......	......	36	29	......	......	
31	Spencer-Lee	5	9	8	10	3	9½	......	Second trial..........	63	61	......	......	
32	Dean	17	10	8	12	1	13	......	......	17	10	......	......	Third trial one cartridge replaced in time allowed.
33	Chaffee-Reece	7	9	12	10	6½	17	......	......	38	25	......	1	Second trial.
34	Hotchkiss	5	9	0	9	7½	17	......	......	31	14	......	5	
35	Spencer-Lee	5	10	0	10	11	9	......	......	69	66	1	5	By inventor.
36	Lee....................	5	8	4	9	0	9	......	......	68	41	......	3	By inventor.
37	Burton	5 5	......		......		35	......	Gun not properly chambered; suspended for modification.	......	......	......	......	
38	Burton	5	......		......		......	......	......do	......	......	......	......	
39	Springfield-Jones.....		9	8	10	0	40	......	By Mr. Hare..........	17	16	......	1	Two cartridges escaped from magazine.
40	Russell-Livermore....	......	9	8	10	0	15	......	By Captain Livermore	43	29	......	3	Third trial by Captain Livermore.

* Detached.

Table showing weights, number of cartridges carried, and the comparative performance of all magazine guns before the Board—Continued.

REGULAR TESTS—Continued.

	Name of gun.	Rapidity with accuracy.					Rapidity at will.							
		As a single loader.					As magazine gun.				As a single loader.			
		Shots.	Hits.	Misfires.	Remained in chamber.	Remarks.	Shots.	Misfires.	Remained in magazine.	Remarks.	Shots.	Misfires.	Remained in chamber.	Remarks.
1	Remington-Keene	36	13		1		17		6	One cartridge escaped from magazine, blocking carrier.	21			
2	Remington-Keene	32	4			Operator much fatigued.	19		5	Two thrown out by carrier.	20			
3	Boch													
4	Hotchkiss	41	8				16		5	Magazine twice cut off	24			
5	Hotchkiss	42	15				19				26			
6	Chaffee-Reece	30	16				21		6		20			
7	Boch	28	23			One cartridge dropped on the ground.	10			Magazine worked with great uncertainty.				Gun withdrawn.
8	Remington-Keene	31	22				17		3	Two cartridges failed to feed up.	21		1	One cartridge dropped down with carrier.
9	Hotchkiss	43	15				19		5		27			Two cartridges dropped on the ground.
10	Lee	27	27		1		11		5		24			
11	Lee	35	31		1		21		13		31			
12	Trabue	29	20		1	Operator much fatigued.	16		7		22			
13	Boch													
14	Russell	35	24			Six shots fell back into the receiver.	21				23			
15	Boch	34	29				19		7		19			One misfire.
16	Marlin	27	22				23		4		20			
17	Russell	29	20		1	One misfire; went on second trial. Three failures to eject.	20	1			19		1	Four left in magazine.
18	Boch													
19	Trabue	40	17				21			One thrown out by false motion of operator.	29			
20	Boch	30	23		1		23		4		23			
21	Trabue	43	8				18		5		30			
22	Dean	29	14							Gun would not work; withdrawn for modification.				

Table showing weights, number of cartridges carried, and the comparative performance of all magazine guns before the Board—Continued.

REGULAR TESTS—Continued.

	Name of gun.	Rapidity with accuracy.					Rapidity at will.							
		As a single loader.					As a magazine gun.				As a single loader.			
		Shots.	Hits.	Misfires.	Remained in chamber.	Remarks.	Shots.	Misfires.	Remained in magazine.	Remarks.	Shots.	Misfires.	Remained in chamber.	Remarks.
23	Dean	26	17		1		20		14			(*)		At fourteenth shot gun broke down.
24	Spencer-Lee	34	32			Gun worked well	27	1		One cartridge failed to feed up. Second trial.	27			Two cartridges thrown out without firing.
25	Dean													
26	Boch	33	18				21		6		21			One cartridge remaining in gun.
27	Remington-Keene	32	24			Gun worked very hard; at thirty-fourth shot stock-tip broke off. Test suspended for repairs.				Withdrawn for modification.				
28	Marlin	36	21				25				23			Gun working well.
29	Remington-Keene	34	21			Gun worked hard				Withdrawn for modification.				
30	Remington-Keene	41	8				22				27			One lost by false motion of operator.
31	Spencer-Lee	37	26				40				20			Third trial. Test suspended for repairs. Finally withdrawn.
32	Dean	23	21			Gun worked hard	17			Five cartridges replaced in time allowed.	10			Gun working very hard.
33	Chaffee-Reece	41	15				23		7		26			
34	Hotchkiss	45	21				23				31			
35	Spencer-Lee	38	34			By Mr. Hare	27		3	One thrown out without firing.	26			
36	Lee	46	31			By Mr. Hare	35				29			
37	Burton													
38	Burton													
39	Springfield-Jones	41	31		1	Four failures to eject	11		1	Six failures to eject	22			Nine failures to eject.
40	Russell-Livermore	44	24			By Mr. Hare	27	1		Captain Livermore	25			By Mr. Hare.

* At fourteenth shot gun broke down.

Table showing weights, number of cartridges carried, and the comparative performance of all magazine guns before the Board—Continued.

REGULAR TESTS—Continued.

	Name of gun.	Endurance.			Defective cartridges.		
		Shots.	Misfires.	Remarks.	Shots.	Misfires.	Remarks.
1	Remington-Keene	500	4	Screw on head of bolt worked out	3		Nos. 1 and 2, liberal escape of gas through ports and over top of bolt; failed to extract; No. 3, slight escape.
2	Remington-Keene	500	2	Misfire; went second trial	3		Nos. 1 and 2, liberal escape of gas through ports and over top of bolt; No. 3, slight escape; failed to extract.
3	Boch						
4	Hotchkiss	500	1	Misfire; went second trial	3		Slight escape of gas.
5	Hotchkiss	500	1	Misfire; went second trial	3		Liberal escape of gas.
6	Chaffee-Reece	500		One of front guard-screws found to be broken	3		Slight escape of gas through gas-port round the bolt.
7	Boch						
8	Remington-Keene	500	1	Opened hard, but worked well; one failure to extract	3		Liberal escape of gas.
9	Hotchkiss	500	1	Caught under bolt in feeding up	3		Liberal escape through ports.
10	Lee	500		First 300 rounds worked stiffly, but easily at close	3		Nos. 1 and 2, free escape of gas; No. 3, no escape.
11	Lee	500		Gun worked well	3		Slight escape of gas.
12	Trabue	500		Failed to extract four times; missed fire once; burst head once.	3		Liberal escape of gas; chamber of gun much enlarged; withdrawn.
13	Boch						
14	Russell	400		Thirty-three cartridges failed to explode; six failed to eject.			After 400 shots gun worked with great difficulty, and decided as broken down; withdrawn.
15	Boch	500	1	Worked badly	3		Liberal escape of gas.
16	Marlin	48		One shot exploded in magazine			Gun withdrawn for repairs.
17	Russell	500	39		3		Liberal escape of gas, but less on second and third shots.
18	Boch						
19	Trabue	500	1	Gun worked well	3		Slight escape of gas.
20	Boch	500		Six failed to eject	3		Liberal escape of gas.
21	Trabue	500		Opened a little hard, but worked easily	3		Liberal escape of gas.
22	Dean						
23	Dean						
24	Spencer-Lee	500		Worked all right	3		Liberal escape of gas.
25	Dean						
26	Boch	500	7	After firing fifty shots, inventor took gun to correct difficulty.	3		Liberal escape of gas.
27	Remington-Keene						
28	Marlin	500		Gun worked well throughout this test	3		Very slight escape of gas.
29	Remington-Keene						
30	Remington-Keene	500		Gun worked very well	3		Liberal escape of gas.

Table showing weights, number of cartridges carried, and the comparative performance of all magazine guns before the Board—Continued.

REGULAR TESTS—Continued.

	Name of gun.	Endurance.			Defective cartridges.		
		Shots.	Misfires.	Remarks.	Shots.	Misfires.	Remarks.
31	Spencer-Lee						
32	Dean			Board decided gun not fit for military purposes; withdrawn for modification.			
33	Chaffee-Reece	500		Gun worked well	3		Liberal escape of gas.
34	Hotchkiss	500		Weakened and loosened butt-stock connection	3		Liberal escape of gas through ports and over head of bolt.
35	Spencer-Lee	500		Fifty shots fired in 1′ 15″	3		Extracted easily; slight escape of gas.
36	Lee	500		Fifty shots fired in 1′ by Mr. Lee; worked well	3		Liberal escape of gas through ports.
37	Burton						
38	Burton						
39	Springfield-Jones			Stock split through head on account of weakness			Gun withdrawn.
40	Russell-Livermore			Fifty shots fired in 1′ 6″; one failure to extract	3		Very large escape of gas in all directions.

Table showing weights, number of cartridges carried, and the comparative performance of all magazine guns before the Board—Continued.

REGULAR TESTS—Continued.

	Name of gun.	Dust.			Rust.			Excess in charges.		
		Shots.	Misfires.	Remarks.	Shots.	Misfires.	Remarks.	Shots.	Misfires.	Remarks.
1	Remington-Keene	40		Second twenty worked a little hard	20		A little hard to open; worked all right.	3		Opened hard.
2	Remington-Keene	40		Two failed to extract	20		Worked freely	3		Opened hard.
3	Boch									
4	Hotchkiss	40		Five failures to extract	20		Opened hard, but worked well	3		Head of shell burst; worked stiffly on last shot.
5	Hotchkiss	40		Worked very well; mainspring broken; not replaced.	20		Worked stiffly	3		Third shot fired twice.
6	Chaffee-Reece	40		Worked very well	20		Opened hard, but worked well	3		Opened hard and worked stiffly.
7	Boch									
8	Remington-Keene	40		Opened with difficulty; worked stiffly; ejector-pin broken; not replaced.	20		Bolt failed to lock; opened easily, and worked all right, except slight stiffness in carrier.	3		Opened very hard on last shot.
9	Hotchkiss	40		Opened easily, and worked smoothly throughout.	20		Slightly rusted; still moist; opened easily, and worked well.	3		Worked well.
10	Lee	40		Worked badly	20		Opened well, but worked stiffly	3		Opened hard; head of shell burst.
11	Lee	40		Worked well	20		Opened easily, and worked well	3		Gun worked well.
12	Trabue			Chamber of gun much enlarged; withdrawn.						
13	Boch									
14	Russell									
15	Boch	40		Gun worked hard; one failure to feed down; one failed to extract.						
16	Marlin									
17	Russell	40	4	Worked stiff first dusting; all right second dusting.	20	5	Worked stiffly	3		Gun worked badly.
18	Boch									
19	Trabue	40		Gun worked well	20		Worked well throughout	3		Opened hard.
20	Boch	40		Worked badly	20		Opened easily	3		Opened hard and failed to extract.
21	Trabue	40		Worked all right	20	1	Opened a little hard	3		Screw found bent and fragment of shell under it.
22	Dean									
23	Dean									
24	Spencer-Lee	40		Worked all right	20	3	Gun badly rusted	3		Head of shell blown off third shot; opened hard.
25	Dean									

Table showing weights, number of cartridges carried, and the comparative performance of all magazine guns before the Board—Continued.

REGULAR TESTS—Continued.

	Name of gun.	Dust.			Rust.			Excess in charges.		
		Shots.	Misfires.	Remarks.	Shots.	Misfires.	Remarks.	Shots.	Misfires.	Remarks.
26	Boch	40	2	Worked fairly	20	18	Misfires; required two blows to explode.	3		Opened hard.
27	Remington-Keene									
28	Marlin	40		Gun worked well	20		Opened with some difficulty	3		Head of shell off; No. 1 failed to extract; No. 2 opened hard; extracted; No. 3 opened with great difficulty.
29	Remington-Keene									
30	Remington-Keene	40		Worked very well	20		Gun well rusted; opened and worked with difficulty.	3		Third shot extractor broken and replaced.
31	Spencer-Lee									
32	Dean			Board decided gun not fit for military purposes; withdrawn for modification.						
33	Chaffee-Reece	40		Worked very well	20		Thoroughly rusted, and worked with great difficulty.	3		Worked as before.
34	Hotchkiss	40		Worked well	20		Opened with great difficulty; failed to work; extractor broken; replaced; dismounted.	3		Shell-head blown through extractor slot; failed to extract.
35	Spencer-Lee	40		One shell stuck slightly, requiring extra force.	20		Thoroughly rusted; opened with difficulty; moistened with water; dismounted before firing shots.	3		Worked well.
36	Lee	40		Gun worked well	20		Opened with some difficulty; being moistened, worked well.	3		Worked well.
37	Burton									
38	Burton									
39	Springfield-Jones									
40	Russell-Livermore	40	1	One failed to extract			Gun thoroughly rusted; could not be worked.			

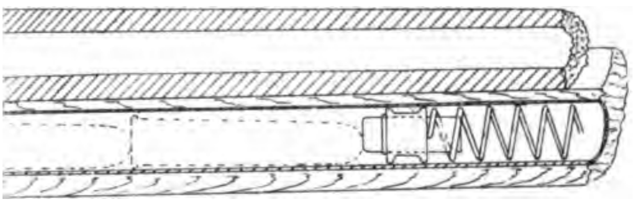
SUPPLEMENTARY TESTS.

Name of gun.	No. of gun.	No. of cartridges carried.	Weights.			First test.		Second test.
			Not loaded.	Fully loaded.		Defective cartridges.	Dust.	Excessive charges, &c.
			Lbs.	*lbs.*	*oz.*			
Marlin	28	9	9¾	10	9½	Large escape of gas, blowing open the magazine feed-gate.	Failed to extract shell twice and failed to eject twice.	Heads of shells all blown off, and opened hard. Cartridges in magazine discolored, and bullets of those nearest the receiver bruised and flattened at the point.
Remington-Keene	30	8	9	9¾		Gun worked well	Gun worked well	Heads of shell burst and blown off; cartridges in the magazine much blackened and the bullets bruised at the points. Large escape of gas, much fouling, and receiver sprung.
Chaffee-Reece	33	7	9¾	10	6½	Gun worked well	Some difficulty encountered in filling and closing the magazine.	Bullets of the first and second cartridges from the receiver slightly flattened at the points.
Hotchkiss	34	5	9	9	7½	Gun worked well	Failed to extract shell once	Gun worked well, but little fouling. Bullets of cartridges in the magazine slightly flattened at the points.
Spencer-Lee	35	5	10	10	11½	Gun worked well	1 misfire	Breech-block partly opened at each shot when in the rest and not locked. Heads of shells somewhat swollen.
Lee	36	5	8½	9		Gun worked well	Gun worked well	Bullets of cartridges in the magazine showed marks of contact with the inside of the magazine.

SUPPLEMENTARY TESTS—Continued.

Name of gun.	No. of gun.	Third test.	Fourth test.—Liability to accidental explosion.			Fifth test.
		Facility of manipulation.	A.	B.	C.	Liability to breakage.
Marlin	28	The usual motions for working a lever-gun required; sometimes a little hard.	Impracticable to work the gun in the fixed rest and this test not applied.	Cartridges nearest the chamber dissolved; bullets flattened at points, all heated and lubricant melted.	Same effects as in B, more marked; at second shot after putting fresh cartridges in the magazine for the second 50, cartridge exploded in the magazine.	....
Remington-Keene	30	The usual motions required for working a bolt-gun with handle in the middle.	17 shots fired; gun broken down. Largely due to insufficient hardening of the receiver. Further test abandoned.	....	....	....
Chaffee-Reece	33	Same remarks as above	Bullets of cartridges in the magazine slightly flattened at the points, the second from the receiver always showing the most.	Not tried with this gun; less effective as a test than the preceding.	Bullet of last cartridge in the magazine (No. 7) sometimes slightly flattened.	Not by ordinary usage.
Hotchkiss	34	Same remarks	Bullets of the cartridges in the magazine flattened at the points and primers showed contact with lead.	Bullets showed less flattening than in the preceding test.	Same remarks as in A	Not by ordinary usage.
Spencer-Lee	35	Easy and rapid	Bullets of cartridges in the magazine but slightly affected.	Not tried in this test	Not tried in this test	Not by ordinary usage.
Lee	36	The usual motions for working a bolt-gun with handle in the rear of the bolt, gun not necessarily taken from the shoulder, or hand from the bolt until magazine is emptied.	Same remarks as above	Gun not readily loaded as a single shooter with magazine filled and attached and test abandoned.	This test deemed unnecessary.	Not by ordinary usage.

PLATE I.



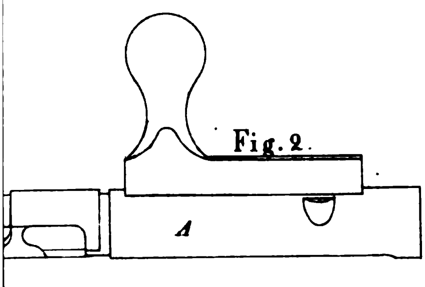
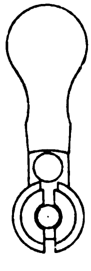


Fig. 2.



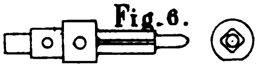
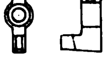


Fig. 6.

Fig. 5.



Appendix 30—1882.

APPENDIX 31.

DEVIATIONS OF SMALL-ARM PROJECTILES.

THE VERTICAL DEVIATION OF THE POINT OF FALL OF SMALL-ARM PROJECTILES FROM THE POINT AIMED AT, WHEN THE LATTER POINT IS ABOVE OR BELOW THE HORIZONTAL PLANE THROUGH THE POINT OF FIRE, MAKING USE OF THE EQUATION OF THE TRAJECTORY.

BY CAPT. JOHN E. GREER, ORDNANCE DEPARTMENT.

(Two plates.)

NATIONAL ARMORY, *September* 1, 1882.

SIR: About two years ago I was requested by the late Colonel Benton to prove—inquiry having been made of him—that a gun accurately sighted on a level, as is customary, for a range, R, would always shoot below the point aimed at if that point were above the horizontal but at the same distance, R, from the firer, and above that point if it were below the horizontal.

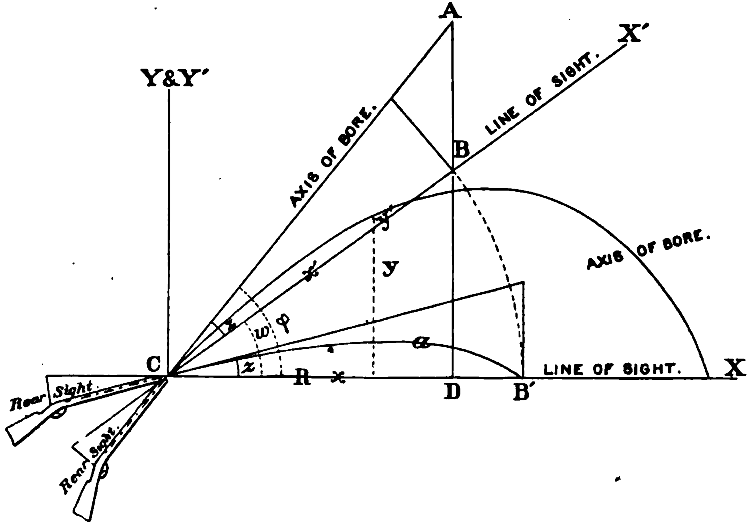
This I was unable to do for the reason, as appears from what follows, that such is not always the case, though I proposed at the time a simple method of finding the distance from the point aimed at, above or below, in any particular instance, by making use of the equation of the trajectory.

Recently I resumed consideration of the subject, and now have the honor to submit a very interesting discussion in regard to it.

The equation of the trajectory *in vacuo* is

$$(1) \qquad y = x \tan z - \frac{gx^2}{2\,V^2 \cos.^2 z},$$

in which x and y are the co-ordinates of the various points of the line referred to the rectangular axes X and Y, z the angle of projection, and V the initial velocity.



The trajectory marked (*a*) in the figure may be considered as corresponding to this equation.

Suppose the object aimed at is under an angle of elevation w, and that the line of sight makes the same angle z with the axis of the bore.

The angle of projection is then $w + z$,* and the equation of the trajectory under these circumstances becomes

$$y = x \tan.(w + z) - \frac{gx^2}{2\,V^2 \cos.^2 (w + z)}$$

The curve marked (*b*) may be considered as corresponding to this equation. For convenience make $\varphi = w + z$, whence we have

$$(2) \qquad y = x \tan.\varphi - \frac{gx^2}{2\,V^2 \cos.^2 \varphi}.$$

Let us now refer this latter trajectory to a new set of co-ordinate axes in the same plane having the same origin, the new and primitive axes of Y being the same but the new axis of X being the new line of sight.

Calling x' and y' the new co-ordinates, we have from the figure:

$$x = x' \cos.w,$$

and

$$y = y' + x' \sin.w.$$

Making these substitutions in equation 2 and reducing, there results,

$$(3) \qquad y' = x' \cos.w \tan.\varphi - x' \sin.w - \frac{gx'^2\,2 \cos.^2 w}{2\,v^2 \cos.^2 \varphi}.$$

From this equation, having given a particular value for x', y' may be readily deduced.

In order, then, to find where the trajectory cuts a vertical target at any range, *substitute for x' the range given and solve the equation with respect to y'.*

If y' be *positive*, the projectile strikes the target *above* the point aimed at; if *negative*, *below*; and if *zero*, at *that point.*

Substituting R, the range, for X′, we have

$$y' = R \cos.w \tan.\varphi - R \sin.w - \frac{g\,R^2 \cos.^2 w}{2\,V^2 \cos.^2 \varphi}.$$

From the figure:

$$C\,D = R \cos.w = A\,C \cos.\varphi$$

$$\therefore R \cos.w \tan.\varphi = A\,C \cos.\varphi \tan.\varphi = A\,C \sin.\varphi,$$

and

$$y' = A\,C \sin.\varphi - R \sin.w - \frac{g\,R^2 \cos.^2 w}{2\,V^2 \cos.^2 \varphi}.$$

But A B = A D − B D and A D and B D equal A C sin. φ and R sin. w, respectively;

$$\therefore A\,B = A\,C \sin.\varphi - R \sin.w.$$

---

* This of course assumes that the position of the muzzle of the piece remains unchanged; otherwise the angle of projection will not be exactly $w + z$, as may be seen in Plate II, where the angle of elevation of the object is w diminished by the angle at the object subtended by the distance through which the muzzle has been raised. The range, however, is usually so great in comparison with the few inches passed over by the muzzle that the latter angle may be neglected without sensible error.

From the triangle A B C we have $AB : R :: \sin. z : \sin. (90^\circ - \varphi)$, from which

$$AB = \frac{R \sin. z}{\cos. \varphi} \therefore \frac{R \sin. z}{\cos. \varphi} = AC \sin. \varphi - R \sin. w,$$

and

$$(4) \qquad y' = \frac{R \sin. z}{\cos. \varphi} - \frac{g R^2 \cos.^2 w}{2 V^2 \cos.^2 \varphi}.$$

But $R = \frac{V^2}{g} \sin. 2z$ (*Benton's Ordnance and Gunnery*, p. 397), whence

$$V^2 = \frac{g R}{\sin. 2z}$$

and

$$y' = \frac{}{\cos. \varphi} - \frac{R \cos.^2 w \sin. 2z}{2 \cos.^2 \varphi} = \frac{R \sin. z}{\cos. \varphi} - \frac{R \cos. z \sin. z \cos.^2 w}{\cos.^2 \varphi}$$

or

$$(5) \qquad y' = \frac{R \sin. z}{\cos.^2 \varphi} (\cos. \varphi - \cos. z \cos.^2 w).$$

But $\varphi = w + z$ and $\cos. \varphi = \cos. w \cos. z - \sin. w \sin. z$,

$$\therefore y' = \frac{R \sin. z}{\cos.^2 \varphi} (\cos. w \cos. z - \sin. w \sin. z - \cos. z \cos.^2 w).$$

Again, $\sin. w = \tan. w \cos. w$ and $\sin. z = \tan. z \cos. z$

$$\therefore y' = \frac{R \sin. z}{\cos.^2 \varphi} (\cos. w \cos. z - \tan. w \cos. w \tan. z \cos. z - \cos. z \cos.^2 w),$$

or,

$$(6) \qquad y^1 = \frac{R \sin. z \cos. z \cos. w}{\cos.^2 \varphi} (1 - \cos. w - \tan. w \tan. z);$$

but $1 - \cos. w = \text{versin.}\, w$; hence

$$(7) \qquad y' = \frac{R \sin. z \cos. z \cos. w}{\cos.^2 \varphi} (\text{versin.}\, w - \tan. w \tan. z).$$

Now, in the first factor of the second member R is positive, being the range; sin. z and cos. z are positive, since z, the angle of elevation as given by the sights on the piece, is always positive, and as w can never exceed 90°, either positive or negative—otherwise a barrel of the piece would be on the under side (Fig. 4, Plate I)—cos. w is always positive. Again, no matter what cos. φ may be, its square is positive. Hence, the first factor of the second member is always positive, and y' depends for its sign on that of the second factor.

Now, versin. w is always positive, w never exceeding 90°, and if the point aimed at be below the horizontal, that is, in the fourth quadrant, w is negative and its tangent is negative.

But tan. z is positive, hence tan. z tan. w is essentially negative, and *minus* tan. z tan. w is positive. Hence the second factor is positive, and therefore y' is positive, that is, the trajectory always passes *above* the point aimed at when that point is *below* the horizontal.

If the point aimed at be above the horizontal, tan. z tan. w will be positive and y' may be positive, negative, or zero, according as $1 - \cos. w$ is greater than, less than, or equal to, tan. z tan. w.

To ascertain whether, with a given angle of elevation, z, there is any value of w which will make $y = 0$, that is, whether there is any point above the horizontal at a range, R, which being aimed at may be hit, the sight on the gun remaining unchanged, place $1-\cos. w = \tan. z \tan. w$, whence

$$\frac{1-\cos. w}{\tan. w.} = \tan. z.$$

Now

$$\cos. w = \frac{1-\tan.^2 \frac{1}{2} w}{1+\tan.^2 \frac{1}{2} w} \text{ and } \tan. w = \frac{2 \tan. \frac{1}{2} w}{1-\tan.^2 \frac{1}{2} w};$$

hence,

$$1-\cos. w = 1 - \frac{1-\tan.^2 \frac{1}{2} w}{1+\tan.^2 \frac{1}{2} w} = \frac{2 \tan.^2 \frac{1}{2} w}{1+\tan.^2 \frac{1}{2} w},$$

and

$$\frac{1-\cos. w}{\tan. w} = \frac{\dfrac{2 \tan.^2 \frac{1}{2} w}{1+\tan.^2 \frac{1}{2} w}}{\dfrac{2 \tan. \frac{1}{2} w}{1-\tan.^2 \frac{1}{2} w}} = \frac{\tan. \frac{1}{2} w - \tan.^3 \frac{1}{2} w}{1+\tan.^2 \frac{1}{2} w} = \tan. z.$$

For convenience, represent $\tan. \frac{1}{2} w$ by x and $\tan. z$ by a, and we shall have

$$\frac{x-x^3}{1+x^2} = a \therefore x^3 + a x^2 - x + a = 0.$$

This, being a numerical equation of the third degree, may be solved by means of limits giving the values of $x = \tan. \frac{1}{2} w$. From a table of tangents, $\frac{1}{2} w$ and hence w may be found.

For example, suppose z, the angle given by the sights for a range, R, to be 1°; its tangent, or a, is 0.0174551, and the equation $x^3 + a x^2 - x + a = 0$ becomes $x^3 + .0174551 x^2 - x + .0174551 = 0$. Solving, we find the values of $x = \tan. \frac{1}{2} w$ to be

$$\left.\begin{array}{r} 0.0174657 \\ 0.982387 \\ -1.0173078 \end{array}\right\} \text{whence } \tfrac{1}{2} w = \left\{\begin{array}{r} 1^\circ\ 0'\ 2''.19 \\ 44^\circ\ 29'\ 27''.4 \\ -45^\circ\ 29'\ 29''.62 \end{array}\right\} \text{and } w = \left\{\begin{array}{r} 2^\circ\ 0'\ 4''.38 \\ 88^\circ\ 58'\ 54''.86 \\ -90^\circ\ 58'\ 59''.24 \end{array}\right.$$

The last value of w, being negative and greater than 90°, must necessarily be rejected. Hence, in this particular case there are two points, one 2° 0′ 4″.38 and the other 88° 58′ 54″.86 above the horizontal and at a distance, R, from the firer, which may be hit, the sight on the gun being that necessary to attain a range, R, on the level.

If the point be above the horizontal and both the angles w and z be given, we may readily find whether the trajectory will pass above, through, or below the point by substituting their values in the second factor of the second member of the equation,

$$y' = \frac{R \sin. z}{\cos.^2 \varphi} (\cos. \varphi - \cos. z \cos^2 w).$$

For instance, if $z = 3^\circ$ and $w = 10^\circ$, φ will equal 13°, and

$$\log. \cos. \varphi - \log. \cos. z - 2 \log. \cos. w =$$
$$\log. \cos. 13^\circ - \log. \cos. 3^\circ - 2 \log. \cos. 10^\circ + 20 =$$
$$9.9887237 - 9.9994044 - 19.9867030 + 20 = .0026165.$$

Hence y' is positive, and the trajectory passes *above* the point aimed at, at a distance equal to 0.00032265 R, as may be found from the above equation, or more conveniently from equation 4.

To show that it is not always the case that the trajectory passes above the point aimed at, take the angles $z = 15^\circ$ and $w = 15^\circ$. whence $\varphi = 30^\circ$;

$$\log.\cos.30^\circ - \log.\cos.15^\circ - 2\log.\cos.15^\circ =$$
$$\log.\cos.30^\circ - 3\log.\cos.15^\circ =$$
$$9.9375306 - 29.9548314 + 20 = -0.0173008.$$

Hence y' is negative, and the trajectory passes *below* the point aimed at at a distance equal to 0.012146 R.

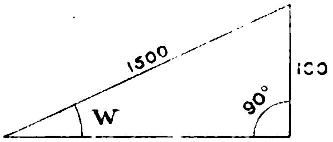
In order to apply this to the trajectory in air it is necessary to introduce the multiplier "B," *Ordnance and Gunnery*, page 413.

Equation 4 then becomes

$$y' = \mathrm{R}\frac{\sin.z}{\cos.\varphi} - \frac{g\,\mathrm{R}^2\cos.^2 w}{2\,v^2\cos.^2\varphi}\mathrm{B}. \qquad (8)$$

B depends for its value on $\frac{x}{c}$ and $\frac{v}{r}$, tables being given from which it may readily be determined when these quantities are known.

X represents the range, V the initial velocity; r, a constant, is 1,427 feet. C is constant for any particular projectile and must be determined by experiment. For example, suppose the range to be 500 yards or 1,500 feet, the point aimed at 100 feet above the horizontal, the arm used the Springfield rifle, the elevation of which for 500 yards is 1° 11′, and the initial velocity 1,335 feet. To find W we have (see figure),



$$100 = 1{,}500\sin.\mathrm{W},$$

whence

$$\log.100 - \log.1{,}500 + 10 = \log.\sin.\mathrm{W},$$

or

$$8.8239087 = \log.\sin.\mathrm{W}.$$

Hence

$$\mathrm{W} = 3^\circ 49' 21''.2, \text{ and } \varphi = 5^\circ 0' 21''.2.$$

C, as determined by Captain Prince, *Ordnance Notes*, No. 4, is 1,943; hence

$$\frac{x}{c} = \frac{1{,}500}{1{,}943} = .772 \text{ and } \frac{\mathrm{V}}{\mathrm{R}} = \frac{1{,}335}{1{,}427} = .9335.$$

From Table I, page 510, *Ordnance and Gunnery*, we find B to be 1.6678.

$$\log.\frac{\mathrm{R}\sin.z}{\cos.\varphi} = \log.\mathrm{R} + \log.\sin.z - \log.\cos.\varphi =$$

$$\log.1{,}500 + \log.\sin.(1^\circ 11') - \log.\cos.(5^\circ 0' 21''.2) =$$

$$3.1760913 + 8.3149536 - 9.9983403 = 1.4927046,$$

and

$$\frac{\mathrm{R}\sin.z}{\cos.\varphi} = 31.095.$$

$$\mathrm{Log.}\frac{g\,\mathrm{R}^2\cos.^2 w}{2\,\mathrm{V}^2\cos.^2\varphi}\mathrm{B} = \log.16.08 + 2\log.\mathrm{R} + 2\log.\cos.w + \log.\mathrm{B}_{-2}$$

$$\log.\mathrm{V}_{-2}\log.\cos\varphi = 1.2062860 + 6.3521826 + 19.9980656 + .2221440$$
$$- 6.2509626 - 19.9966806 = 1.5310350,$$

and

$$\frac{g\,\mathrm{R}^2\cos.^2 w}{2\,\mathrm{V}^2\cos.^2\varphi}\mathrm{B} = 33.965.$$

Making these substitutions in equation 8, we have $y'=31.095-33.965=-2.87$ feet, or the projectile strikes 2.87 feet below the object.

As "B" is always greater than unity—as may be seen by an inspection of Table I, *Ordnance and Gunnery*—it follows that the probability of the last term of the second member of equation 8 exceeding the first increases as B increases.

In fact, the resistance of the air by retarding the projectile increases the interval of time necessary for it to pass over the distance R, and therefore it falls farther below the axis of the bore prolonged than indicated by the equation *in vacuo*. In all probability this is sufficient to cause it to strike below the point aimed at in all cases when that point is above the horizontal, though, as before stated, it can only be determined definitely, in any particular case, by application of the equation last referred to.

The same may also be the case when the point is below the horizontal, since, if the equation 8 be operated on in a manner similar to that employed in deriving equation 6 from equation 4, there will result

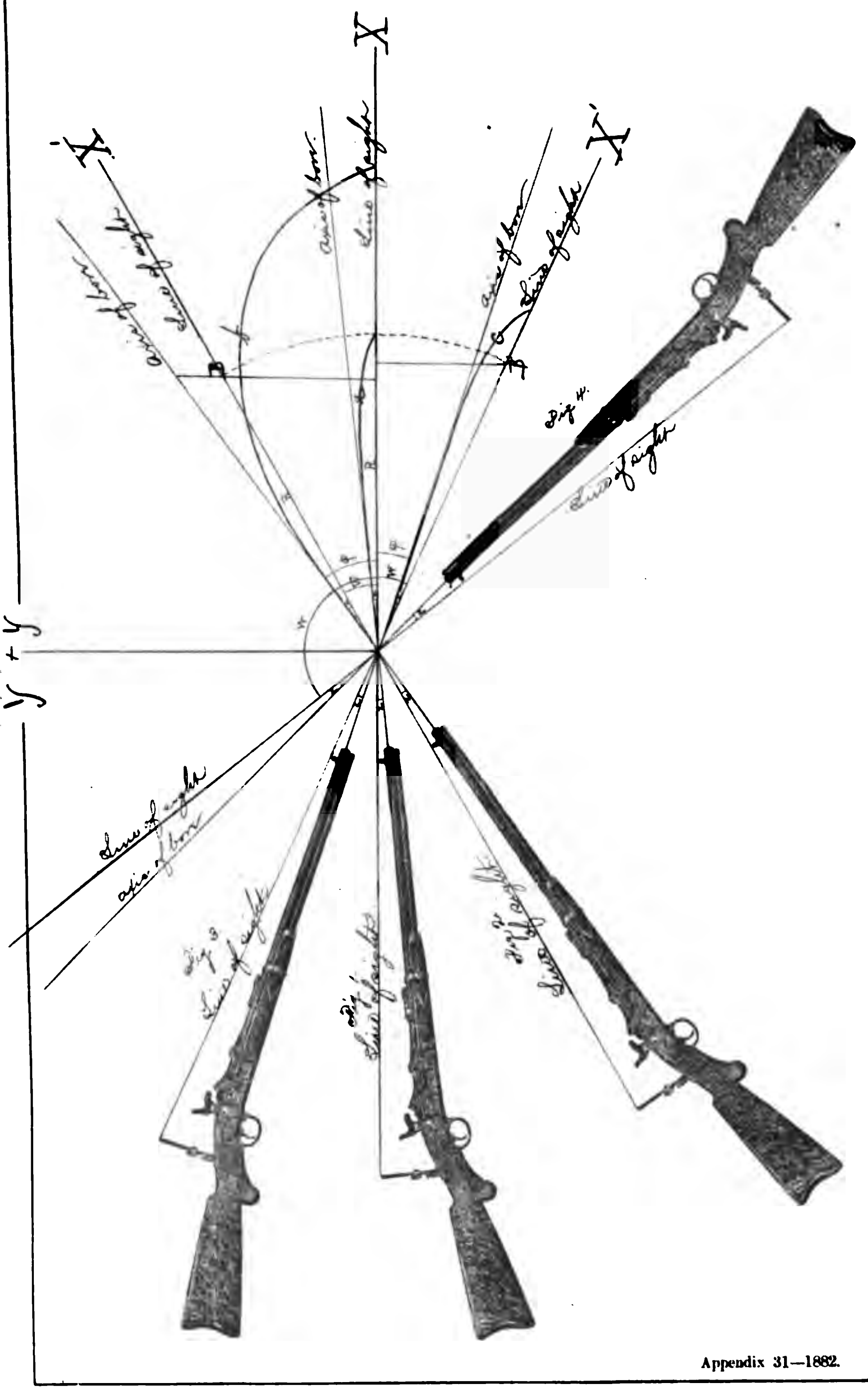
$$y'=\mathrm{R}\frac{\sin. z \cos. z \cos. w}{\cos.^2 \varphi}(1-\mathrm{B}\cos. w-\tan. w \tan. z).$$

The point being below the the horizontal w is negative, and the above becomes

$$y'=\mathrm{R}\frac{\sin. z \cos. z \cos. w}{\cos.^2 \varphi}(1-\mathrm{B}\cos. w+\tan. w \tan. z).$$

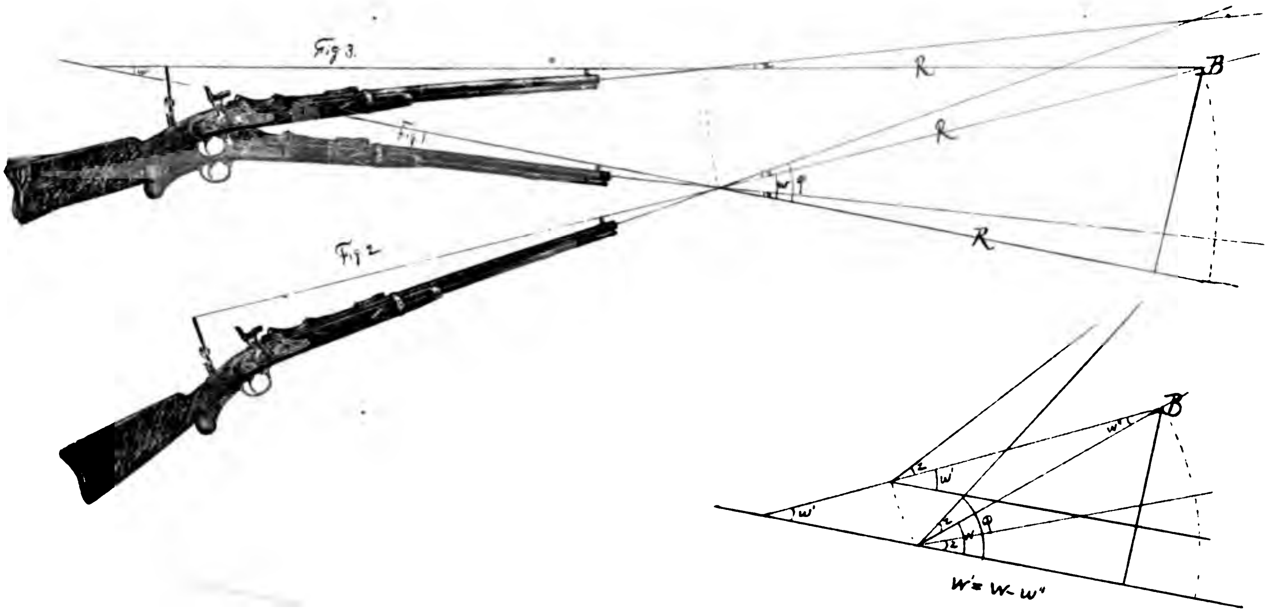
If the resistance of the air be very great, B cos. w may be greater than the sum of all the other terms in the last factor of the second member, in which case y' will be negative and the projectile will strike *below* the object aimed at.

PLATE I.



Origin taken at intersection of line of sight and axis of bore – a few inches in advance of muzzle.

Appendix 31—1882.



Appendix 31—1882.

APPENDIX 32

SHOWING STATIONS AND DUTIES OF THE OFFICERS OF THE ORDNANCE DEPARTMENT ON THE 1ST OF OCTOBER, 1882.

Rank and name.	Duty.	Address.
BRIGADIER-GENERAL.		
Stephen V. Benét	Chief of Ordnance	Washington, D. C.
COLONELS.		
1. T. T. S. Laidley, brevet	Commanding the Watertown Arsenal.	Watertown, Mass.
2 J. McAllister, brevet	Commanding the Benicia Arsenal	Benicia, Cal.
3. S. Crispin, brevet	Commanding the Ordnance Agency	Corner of Houston and Greene streets, New York. Post-office box 1811.
LIEUTENANT-COLONELS.		
1. T. G. Baylor, brevet colonel	Commanding the New York Arsenal, and president of the Ordnance Board.	Governor's Island, New York Harbor. Post-office box 1449.
2. J. M. Whittemore	On duty in the office of the Chief of Ordnance.	Washington, D. C.
3. A. R. Buffington	Commanding the National Armory	Springfield, Mass.
4. D. W. Flagler, brevet	Commanding the Rock Island Arsenal.	Rock Island, Ill.
MAJORS.		
1. A. Mordecai, brevet lieutenant-colonel.	Commanding the Watervliet Arsenal.	West Troy, N. Y.
2. S. C. Lyford, brevet lieutenant-colonel.	Commanding the Frankford Arsenal.	Philadelphia, Pa.
3. F. H. Parker, brevet	Commanding the Piccatinny Powder Depot.	Dover, N. J.
4. J. P. Farley	Commanding the Kennebec Arsenal.	Augusta, Me.
5. L. S. Babbitt	Commanding the Fort Monroe Arsenal.	Fort Monroe, Va.
6. W. A. Marye	Commanding the Augusta Arsenal	Augusta, Ga.
7. I. Arnold, jr	Commanding the Indianapolis Arsenal.	Indianapolis, Ind.
8. C. Comly	Instructor of Ordnance and Gunnery, United States Military Academy.	West Point, N. Y.
9. J. R. McGinness, brevet	Commanding the Saint Louis Powder Depot.	Jefferson Barracks, Mo.
10. G. W. McKee, brevet	Member of the Ordnance Board	Governor's Island, New York Harbor. Post-office box 1449.
CAPTAINS.		
1. J. H. Rollins, brevet	On sick leave	Columbia, Mo.
2. F. H. Phipps, brevet	Assistant, Rock Island Arsenal	Rock Island, Ill.
3. J. W. Reilly, brevet	Commanding the Allegheny Arsenal	Pittsburgh, Pa.
4. J. A. Kress, brevet major.	Commanding the San Antonio Arsenal, and Chief Ordnance Officer Department of Texas.	San Antonio, Tex.
5. O. E. Michaelis, brevet	Assistant, Frankford Arsenal	Philadelphia, Pa.
6. C. E. Dutton	On duty under the Interior Department.	Geological Survey, Washington, D. C.
7. J. G. Butler	Assistant, Watertown Arsenal	Watertown, Mass.
8. C. Bryant	Commanding the Vancouver Barracks Ordnance Depot, and Chief Ordnance Officer Department of the Columbia.	Vancouver, Washington Territory.
9. A. L Varney	Assistant, Watervliet Arsenal	West Troy, N. Y.
10. J. C. Clifford	do	Do.
11. J. E. Greer	Assistant, National Armory	Springfield, Mass.
12. J. Pitman	Assistant, Watertown Arsenal	Watertown, Mass.
13. C. Shaler	Member of the Ordnance Board	Post-office box 1449, New York City.
14. H. Metcalfe	Assistant, Benicia Arsenal	Benicia, Cal.
15. W. S. Starring	Assistant to the Ordnance Board	Post-office box 1449, New York City.
16. C. S. Smith	Principal Assistant in the Ordnance Bureau.	Washington, D. C.
17. S. E. Blunt	Chief Ordnance Officer, Department of Dakota.	Saint Paul, Minn.

Stations and duties of the officers of the Ordnance Department on the 1st of October, 1882—Continued.

Rank and name.	Duty.	Address.
CAPTAINS—Continued.		
18. F. Heath	Commanding the Cheyenne Ordnance Depot.	Cheyenne, Wyo.
19. D. M. Taylor, A. D. C	Chief Ordnance Officer, Department of the Missouri, and commanding the Fort Leavenworth Ordnance Depot.	Fort Leavenworth, Kans.
20. D. A. Lyle	On foundry duty, and member of the Board on Life-saving Apparatus, &c., under the Secretary of the Treasury.	South Boston Foundry, Boston, Mass.
FIRST LIEUTENANTS.		
1. J. Rockwell, jr	Commanding the Fort Abraham Lincoln Ordnance Depot.	Fort Abraham Lincoln, Dak.
2. J. C. Ayres	Assistant, National Armory	Springfield, Mass.
3. M. W. Lyon	Assistant, Frankford Arsenal	Philadelphia, Pa.
4. C. W. Whipple	On foundry duty	West Point Foundry, Cold Spring, N. Y.
5. A. H. Russell	Commanding Fort Lowell Ordnance Depot.	Tucson, Ariz.
6. R. Birnie, jr	Assistant, on foundry duty	West Point Foundry, Cold Spring, N. Y.
7. I. MacNutt	Chief Ordnance Officer, Department of the South.	Newport, Ky.
8. C. C. Morrison	Assistant, National Armory	Springfield, Mass.
9. F. Baker	Assistant, Benicia Arsenal	Benicia, Cal.
10. O. B. Mitcham	Assistant, Rock Island Arsenal	Rock Island, Ill.
11. H. D. Borup	Assistant, on foundry duty	South Boston Foundry, Boston, Mass.
12. L. L. Bruff	Assistant, Rock Island Arsenal	Rock Island, Ill.
13. C. H. Clark	Acting Assistant Instructor of Ordnance and Gunnery.	West Point, N. Y.
14. W. M. Medcalfe	Acting Assistant Professor of Mathematics.	Do.
15. William Crozier	do	Do.
16. W. B. Gordon	Assistant, Frankford Arsenal	Philadelphia, Pa.
ORDNANCE STOREKEEPERS.		
W. Adams, captain	On duty, Fort Monroe Arsenal	Fort Monroe, Va.
A. S. M. Morgan, captain	On duty, Allegheny Arsenal	Pittsburgh, Pa.
W. H. Rexford, captain	On duty, Indianapolis Arsenal	Indianapolis, Ind.
D. J. Young, captain	On duty, Watervliet Arsenal	West Troy, N. Y.
M. J. Grealish, captain	On duty, Augusta Arsenal	Augusta, Ga.
V. McNally, captain	On duty, Ordnance Office	Washington, D. C.

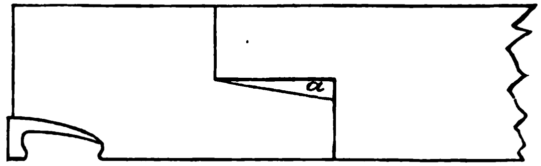
APPENDIX 33.

PROOF OF 11-INCH BREECH-LOADING CHAMBERED RIFLE NO. 1.

BY CAPT. CHARLES S. SMITH, ORDNANCE DEPARTMENT.

U. S. ORDNANCE PROVING GROUND,
Sandy Hook, N. J., September 24, 1881.

GENERAL: I have the honor to transmit herewith record of proof of 11-inch B. L. chambered rifle No. 1, with record of star gauging. The record shows the development of certain defects in the chamber—commencing with the first round and increasing somewhat in gravity as the firing progressed—in the solid forged ring, forming the gas-check seat along the weld, uniting it to the coiled tube. These defects seem to indicate either that the metal in the ring is of a more compressible nature than that in the coiled tube, or that a perfect weld has not been fully secured, which, from the form of the welding surfaces, is not an impossibility. The necessary compression to make a perfect butt-weld would have a tendency to cause a separation in the lap-weld, and thus leave a space or pocket, as in sketch (see *a*), to be afterwards filled by the crowding in of the metal in firing. The difficulty finally experienced in closing and opening the breech was chiefly due, it is thought, to the slight protusion of the gas-check seat in rear. If the latter has now attained a solid bearing, the breech-block can be readily adjusted thereto, and further difficulty from this source should not be apprehended.



The defects in the chamber are not considered serious as yet, and, provided they do not undergo material enlargement hereafter in firing, should not impair the serviceableness of the gun, other than that the rupture of the continuity of the surface greatly facilitates the progress of erosion. The abrupt shoulder now formed along the line of separation at the weld can probably be removed by grinding down, and the evenness of the surface of the chamber thus be restored. If deemed desirable, possibly a narrow copper ring could be let in to an under-cut in the surface of the chamber, and thus protect the joint at the weld.

The results of the further trial of this gun, so far as they relate to the test of the mode of constructing the bottom of the tube, will be of special importance, in view of their bearing on similar constructions—the tubes for the 11-inch and 12 inch B. L. rifles—now undergoing fabrication. I have the honor to await your further instructions.

Very respectfully, your obedient servant,

CHAS. S. SMITH,
Assistant to the Constructor of Ordnance.

CHIEF OF ORDNANCE, U. S. A.,
Washington, D. C.

[First indorsement.]

ORDNANCE OFFICE, WAR DEPARTMENT,
Washington, September 26, 1881.

Respectfully returned to the Constructor of Ordnance, who will, after proof, turn over this gun to the Ordnance Board with this report.

S. V. BENÉT,
Brigadier-General, Chief of Ordnance.

[Second indorsement.]

UNITED STATES ORDNANCE AGENCY,
146 GREENE STREET,
New York, September 27, 1881.

Respectfully referred to the Ordnance Board, U. S. A., for its information.

CHAS. S. SMITH,
Captain of Ordnance, Assistant to Constructor of Ordnance.

[Third indorsement.]

ORDNANCE BOARD, U. S. A.,
New York, November 1, 1881.

Respectfully returned to the Chief of Ordnance, U. S. A.

The 11-inch B. L. rifle referred to within was turned over to the Board on the 27th of September. On the 21st and 22d of October this gun was fired by the Board, and at the 10th round, 18th round in all, the piece burst. A report of this firing will be made hereafter.

For the Board.

T. G. BAYLOR,
Lieutenant-Colonel of Ordnance, Senior Member Present.

Star-gauging of 11-*inch breech-loading chambered rifle No.* 1.

Inches from muzzle.	Original diameter of bore.	Diameter after 8 rounds.	Enlargement after 8 rounds.	Inches from muzzle.	Original diameter of bore.	Diameter after 8 rounds.	Enlargement after 8 rounds.
	Inches.	*Inches.*	*Inches.*		*Inches.*	*Inches.*	*Inches.*
130½	11.004	11.052	0 048	85	11.005	11.030	0.025
130	11.006	11.037	.031	84	11.005	11.030	.025
129	11.005	11.033	.028	83	11.005	11.030	.025
128	11.005	11.031	.026	82	11.005	11.030	.025
127	11.005	11.029	.024	81	11.005	11.030	.025
126	11.005	11.028	.023	80	11.005	11.029	.024
125	11.005	11.025	.020	78	11.005	11.028	.023
124	11.005	11.023	.018	76	11.005	11.027	.022
123	11.005	11.023	.018	74	11.005	11.026	.021
122	11.005	11.023	.018	72	11.005	11.025	.020
121	11.005	11.021	.016	70	11.004	11.023	.019
120	11.005	11.019	.014	68	11.004	11.020	.016
119	11.005	11.018	.013	66	11.004	11.022	.018
118	11.005	11.017	.012	64	11.005	11.021	.016
117	11.005	11.017	.012	62	11.005	11.020	.015
116	11.004	11.017	.013	60	11.005	11.019	.014
115	11.004	11.017	.013	58	11.005	11.018	.013
114	11.004	11.017	.013	56	11.005	11.019	.014
113	11.003	11.016	.013	54	11.004	11.020	.016
112	11.003	11.015	.012	52	11.004	11.019	.015
111	11.003	11.015	.012	50	11.004	11.018	.014
110	11.003	11.015	.012	48	11.003	11.018	.015
109	11.003	11.015	.012	46	11.003	11.018	.015
108	11.003	11.015	.012	44	11.003	11.015	.012
107	11.004	11.015	.011	42	11.003	11.014	.011
106	11.004	11.015	.011	40	11.002	11.010	.008
105	11.004	11.015	.011	38	11.002	11.009	.007
104	11.005	11.015	.010	36	11.001	11.008	.007
103	11.005	11.015	.010	34	11.001	11.007	.006
102	11.005	11.015	010	32	11.000	11.006	.006
101	11.005	11.015	.010	30	11.000	11.005	.005
100	11.005	11.015	.010	28	11.000	11.005	.005
99	11.006	11.013	.010	26	11.000	11.005	.005
98	11.000	11.012	.012	24	11.000	11.005	.005
97	10.999	11.011	.012	22	11.000	11.005	.005
96	10.995	11.014	.019	20	11.001	11.005	.004
95	10.995	11.015	.020	18	11.002	11.005	.003
94	10.997	11.017	.020	16	11.003	11.005	.002
93	11.000	11.022	.022	14	11.002	11.005	.003
92	11.000	11.024	.024	12	11.002	11.005	.003
91	11.001	11.026	.025	10	11.002	11.005	.003
90	11.003	11.028	.025	8	11.002	11.005	.003
89	11.003	11.029	.026	6	11.002	11.004	.002
88	11.004	11.030	.026	4	11.001	11.003	.002
87	11.004	11.030	.026	2	11.001	11.004	.008
86	11.005	11.031	.026	1	11.001	11.004	.003

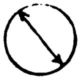
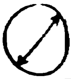
Record of firing with 11-inch breech-loading chambered rifle No.

Sept. 24, 1881.	Number of fire.	Time.	Powder.		Projectile.		Elevation in degrees.
			Kind.	Weight, pounds.	Kind.	Weight, pounds.	
A. M.—Barometer, 30.104; thermometer, 77; relative humidity, 79; wind, 4 miles an hour.	1	1881. Sept. 24	Du Pont's hexagonal F. P. D. No. 11. Density, 1.785; granulation, 67.	115	Hotchkiss shot, 1 copper band; brought up to weight by filling cavity with from 7 to 9 pounds of sand.	550	—1
	2	Sept. 24	....do	115	....do	550	—
P. M.—Barometer, 30.041; thermometer, 85; relative humidity, 61; wind, 13 miles an hour.	3	Sept. 24	....do	120	....do	550	—1
	4	Sept. 24	....do	125	... do	550	—1
	5	Sept. 24	....do	130	... do	550	—1
	6	Sept. 24	Du Pont's hexagonal I. O. A. No. 2. Density, 1.785; granulation, 67.	120	....do	550	—1
	7	Sept. 24	....do	120	....do	550	—
	8	Sept. 24	Du Pont's hexagonal F. P. D. No. 11. Density, 1.785; granulation, 67.	130	....do	550	—1

at Sandy Hook, N. J., September 24, 1881.

Pressure, pounds per square inch of bore.	Instrumental velocity taken at 108 feet from muzzle.	Recoil.	Counter-recoil.	Amount of swedge over band on projectile.		Special remarks about each fire, such as effect on piece, sound of projectile in flight, scattering of fragments, &c.
	Feet.	*Feet.*	*Feet.*	*Inches.*		
28,000	1,345	6.67	.33	.015	Fired into sand butt.	Round 1. Breech opened easily after firing. Slight escape of gas across rear face of gas check. A separation was observed along the weld uniting the solid forged ring, for seat of gas check, with the coiled tube, 4.75 inches in length and .05 inch deep in the middle, and gradually growing less towards each end, apparently due to the condensation of the softer metal of the ring and to imperfect welding at that point. There was no separation in a longitudinal direction. The position of this separation is on the right lower half of the bore and 4.5 inches from the bottom. On the lower left side, also, was a slight depression apparent to the eye but not sensible to the touch.
28,000	1,350	5.67	.33	.015		Round 2. Breech opened easily. Slight escape of gas across rear face of gas check. The observed separation had extended in length to 5.5 inches, and in depth to 0.11 inch. The observed depression on the other side was slightly increased so as to become sensible to the touch.
27,500	1,386	5.75	.33	.015		Round 3. Breech opened easily. About same escape of gas as before. Depth of separation increased to about .013 inch. Depression a little more sensible. In loading, the projectile entered rifled portion of bore .05 inch farther than in previous rounds.
29,500	1,389½	5.75	.33	.040		Rounds 4 and 5. Breech opened easily. Escape of gas about the same as before. No apparent increase in either the separation or the depression.
30,000	1,437	5.75	.33	.040		
49,500	1,442	5.42	.33	.015		Round 6. Breech opened hard. Some escape of gas across rear face of gas check. No marked change in appearance of chamber, unless a gradual extension of the process of condensation or letting out in the ring. Gas-check seat had become projected beyond the cast-iron casing at the side about .01 inch.
43,500	1,451	5.25	.33	.040		Round 7. Breech closed and opened hard. Some enlargements of defects noticed in chamber. No further extension of gas-check seat to rear.
35,000	1,434	5.17	.33	.015		Round 8. Breech closed and opened hard. Length of separation increased to 6 inches; depth, 0.17 inch; with slight erosion at lower extremity. Condensation or letting out metal in forged iron ring had extended completely around the bore along the weld, forming quite a sensible depression. For further particulars see star-gauging report made after this round.

Star-gauging of chamber of 11-*inch breech-loading chambered rifle No.* 1.

Inches from bottom of bore.	Original diameter of bore.		Vertical diameter after 8 rounds.	Horizontal diameter after 8 rounds.		
	Vertical.	Horizontal.			Diameter after 8 rounds.	Diameter after 8 rounds.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
2½	11.996	11.996	12.015	12.027	12.025	12.033
3	11.995	11.996	12.028	12.070	12.052	12.077
3½	11.999	11.996	12.052	12.104	12.110	12.112
4	12.000	11.996	12.070	12.138	12.194	12.131
4½	12.000	11.996	12.063	12.128	12.234	12.111
5	12.000	11.997	12.034	12.054	12.039	12.042
5½	12.000	11.997	12.024	12.030	12.024	12.028
6	....	....	12.023	12.025	12.022	12.023
6½	12.000	11.997	12.023	12.023	12.020	12.022
7	....	....	12.023	12.020		
7½	12.000	11.997	12.021	12.020	The arrows in the circle above show position of movable points on star-gauge.	
8½	12.000	11.997	12.020	12.020		
9½	12.000	11.997	12.020	12.019		
10½	12.000	11.997	12.019	12.018		
11½	12.000	11.997	12.018	12.017		
12½	12.000	11.997	12.018	12.017		
13½	12.000	11.997	12.018	12.016		
14½	12.000	11.997	12.016	12.016		
15½	12.000	11.997	12.015	12.015		
16½	12.000	11.997	12.015	12.015		
17½	12.000	11.997	12.014	12.014		
18½	12.000	11.997	12.014	12.015		
19½	12.000	11.997	12.015	12.015		
20½	12.000	11.967	12.015	12.015		
21½	12.001	11.997	12.016	12.015		
22½	12.001	11.997	12.016	12.015		
23½	12.001	11.993	12.017	12.015		
24½	12.002	11.998	12.017	12.016		
25½	12.003	11.998	12.018	12.015		
26½	12.003	11.999	12.018	12.017		
27½	12.003	11.999	12.019	12.018		
28½	12.003	12.000	12.020	12.020		
29½	12.003	12.001	12.023	12.022		
30½	12.004	12.001	12.024	12.029		
31½	12.005	12.002	12.025	12.023		
32½	12.004	12.003	12.025	12.024		
33½	12.006	12.003	12.027	12.034		
34½	12.034	12.034	12.056	12.055		

APPENDIX 34.

REPORT ON THE 11-INCH BREECH-LOADING CHAMBERED RIFLE NO. 1.

(2 plates.)

THE ORDNANCE BOARD, UNITED STATES ARMY,
New York City, January 16, 1882.

SIR: I have the honor to transmit herewith report of the Ordnance Board on the 11-inch breech-loading chambered rifle.

Very respectfully, your obedient servant,

T. G. BAYLOR,
Lieutenant-Colonel of Ordnance,
President of the Board.

CHIEF OF ORDNANCE, U. S. A.,
Washington, D. C.

The Board assumes that a description of this gun has already been presented to you by the Constructor of Ordnance, and also its record of eight proof rounds.

It was turned over to the Board by your direction for further trial, and 100 rounds of service charges were fixed upon as the test.

The trial commenced on October 21, 1881, with 130 pounds of powder, F. P. D. No. 11, density 1.785; granulation 67, and Hotchkiss projectiles weighing 548 pounds. After the 16th round the recorded pressures and velocities were deemed too low for the work required of a gun of this caliber, and the Board concluded to change the quality of the powder and use one which it was known from previous experiments could produce a higher pressure and velocity. After the second round with this new powder—I. O. A. No. 1, density 1.785, granulation 67—the gun burst, the fracture indicating longitudinal weakness, as the rupture was nearly in a plane perpendicular to the axis of the bore and passing through the plane of the front end of the slot in breech-receiver. (The line of fracture is shown in Plate II.)

The opinions of experts as to the quality of the steel of the breech-receiver are also inclosed, marked B, C, and D. A copy of the record of firing is also inclosed.

The Board is informed that mechanical tests were made of the steel in this gun both before and after the firing, and that these tests show a low quality of steel. The record of these tests is in the possession of the Assistant to Constructor of Ordnance, and it is suggested that a copy be filed with these papers.

The early rupture of this gun, where the pressures had not been excessive, in connection with the unanimous opinion of the experts, together with the record of the mechanical tests, indicates an inferior quality of steel in the breech-receiver.

Target record of firing with 11*-inch breech-loading rifle No.* 1,

	Number of fire.	Time.	Powder.		Projectile.		Elevation in degrees.
			Kind.	Weight, pounds.	Kind.	Weight, pounds.	
		1881.					
Barometer, 30.40; thermometer, 61; relative humidity, 54 per cent.; wind, 8 miles an hour.	9	Oct. 21	Du Pont's hexagonal F. P. D. No. 11. Density 1.785; granulation 67.	130	Hotchkiss (resaboted).	548	—¾
	10	Oct. 21	......do	130	Hotchkiss (new).	548	—¾
	11	Oct. 21	......do	130	Hotchkiss (resaboted).	548	—¾
	12	Oct. 21	..... do	130	Hotchkiss (new).	548	—¾
	13	Oct. 21	......do	130	Hotchkiss (resaboted).	548	—1
	14	Oct. 21	......do	130	Hotchkiss (new).	548	—1
	15	Oct. 21	..... do	130	Hotchkiss (resaboted).	548	—1
	16	Oct. 21	......do	130	... do	548	—1
Barometer, 30.331: thermometer, 58; relative humidity, 63 per cent.; wind, 6 miles an hour.	17	Oct. 22	Du Pont's hexagonal I. O. A. No. 1. Density 1.765; granulation 67.	120	....do	548	—¾
	18	Oct. 22	..... do	120	....do	548	—¾

chambered at Sandy Hook, N. J., October 21 *and October* 22, 1881.

Pressure, pounds per square inch of bore.	Instrumental velocity taken 16 feet from gun.	Recoil.	Counter-recoil.	Direction of wind as regards line of fire.	Kind of pressure gauge.		Special remarks about each fire, such as effect on piece, sound of projectile in flight, scattering of fragments, and velocities taken by two Le Boulengé chronographs. Independent circuits.
	Feet.	*Feet.*	*Feet.*				
36, 000	1, 429	5. 58	0. 33	From front.	Rodman	Fired into sand butts.	Closed and opened easily. Slight escape of gas around outside of check.
32, 000	1, 404	5. 50	. 33		Woodbridge.		Closed easily and opened hard. Slight escape of gas around outside of check.
30, 500	1, 420	5. 50	. 33		Rodman		Closed easily and opened hard. Slight escape of gas around outside of check.
31, 600	1, 404	5. 50	. 33		Woodbridge.		Closed easily, opened easily. Gas escaped on right side from top to bottom.
34, 000	1, 422	5. 58	. 33		Rodman		Closed easily, opened easily. Gas escaped on right side from top to bottom.
31, 600	1, 427	5. 58	. 42		Woodbridge.		Closed hard, opened hard at start. Slight escape of gas on right side of check.
32, 500	1, 431	5. 83	. 17		Rodman		Closed hard, opened easily. Slight escape of gas on right side of check.
31, 200	1, 413	5. 83	. 17		Woodbridge.		Closed hard, opened easily. Slight escape of gas on right side of check.
46, 000	1, 446	......	......	From rear and right.	Rodman		Closed and opened easily. Slight escape of gas on right side of check.
37, 000	1, 411	......	......		Woodbridge.		Closed easily. Breech block and receiver parted from gun, first tearing out corner of barricade erected in rear of gun, then striking ground 78 feet from gun, and then plank road 127 feet; coming to rest at 137 feet on ground. One piece of gas check found 75 yards in rear and 600 yards to right of gun.

B.

HARTFORD, *November* 16, 1881.

DEAR SIR: In answer to your request for a test of the fracture-surfaces of the 8-inch and 11-inch rifles, burst in proving at Sandy Hook, I have the honor to state that I have carefully made a practical test of the surfaces exposed by the fracture for homogeneousness of the same. I have had considerable experience in judging large bodies of steel, since I served my practical apprenticeship in the cast-steel works of Fr. Krupp, Essen, and for many years since, when opportunity served. By mere observation of the fracture I concluded that the steel is soft but rather "short," the 8-inch more so than the 11-inch. I now proceeded to the test of hardness, comparing many points of the fracture-surface with each other. I used one instrument made of the best English tool-steel procurable, had it drawn out to a fine edge and carefully annealed to make it as soft as possible; the second tool made of the same steel was ground to a fine knife-edge, and after hardening was drawn to a temper of dark blue, corresponding to a temperature of about 570°. On trial I found, as anticipated, the greater part of the fracture in both guns softer than my annealed tool, and therefore was able with above two tools to make the test. I commenced with the 8-inch gun. Calling the degree of hardness of the greater part of the exposed surface 0 (zero), my annealed tool one, the dark-blue tempered tool two, I applied the tools to a great number of spots on the surface, with below result. Inclosed you will find a sketch (Plate I) showing the result of the test as near as possible on small scale. On testing the tools themselves the dark blue one easily cut and scratched the annealed tool. On the fracture of the 8-inch gun I found the upper or top part very uniform in hardness 0, with exception of the edges surrounding the bore; here it was from 1 to 1¼ hard; but this was evidently due to compression of the atoms in consequence of the mechanical action of the boring tool, as the same slight degree of greater hardness showed along the edges of the seat of breech-block. In the lower part of the surface, where a portion had been cut out by drilling, I found the greater part like the upper of 0 hardness; but I here discovered a number of seams where the annealed tool (1) could make no impression, and where even the dark-blue tool (2) would not cut, showing the steel to be in fine seams much harder than in any other part. These hard places are marked (3) in the diagram. While I could not discover in the surface of the upper part any seams like these in the lower surface, I found that slightly in the rear of the fracture, where some parts had been cut out of the top by drilling, there were plain indications of similar seams, as the cut by the drill plainly showed; being in some of the drill-holes smooth from top to botton, in others showing plainly where the drill had struck these hard seams. Summing up the above, I find the steel as shown in the fracture of the 8-inch gun of a very soft kind, with parts showing very little variation of hardness; but with the very serious defect of seams with a much higher grade of hardness running through the softer parts. Using the same instruments as before, representing 0 grade of hardness below the annealed tool (1), the annealed tool, and (2) the dark-blue tempered tool, I now tested the 11-inch gun. As shown in the diagram, the greater part of the fracture-surface shows a degree of hardness below the annealed tool, the slightly harder parts along the edges of finished parts are as in the 8-inch gun. But in homogeneousness this steel is superior to the other, as it has no seams, and with exception of (2) small spots where the hardness rises to (2), shows very evenly throughout the fracture, no part rising beyond (2), *i. e.*, no part was harder than the dark-blue tool, which in certain seams would not touch the 8-inch gun. I therefore do not hesitate to state that the steel of the 11-inch gun is superior to that of the 8-inch, according to the evenness of hardness as shown by the surfaces of the fracture.

In concluding this report, I have the honor to call your attention to the fact that specimens cut from the 8-inch gun, so that the hard seams indicated are at right angles to the longitudinal axis of the specimen, should show a decided difference in the testing-machine from such containing no such hard seam.

I am, very respectfully, yours,

C. J. EHBETS.

Captain STARRING, U. S. A.

C.

NEWARK, N. J., *January* 9, 1882.

DEAR SIR: I found the gun to which you called my attention at Sandy Hook to be made of steel unusually weak. The pieces broke off under blows of the sledge with surprising ease. In order to ascertain most positively the cause of this, I have had samples of the pieces broken off carefully analyzed, and find as follows:

Phosphorus, .095; sulphur, .247; silica, .179; carbon, .427.

This analysis indicates the use of poor material in the manufacture of the steel, and largely accounts for its weakness. It is my opinion, however, that the great want of strength is not wholly due to the poorness of the material, but in part to the steel having been, I believe, made too hot in the forging.

Very truly, yours,

J. ILLINGWORTH.

W. S. STARRING, *Captain of Ordnance.*

D.

JERSEY CITY, N. J., *January* 7, 1882.

DEAR SIR: The delay in my giving a report on 11-inch rifle was owing to my waiting for an analysis of the steel, but I will give an opinion without the analysis. The steel showed great weakness in breaking pieces off the gun with a sledge, and this weakness comes from impurities in the iron from which the steel was made. The two pieces I brought with me I had rolled to about ½-inch thick and tried to bend the pieces cold, but they both broke before coming together, showing that the steel has very little *ductility*, and ductility, I think, is absolutely necessary in steel for a gun. Steel may have high tensile strength and low ductile strength, and this seems to be the nature of this gun, and, in my opinion, is not the quality of steel to make a good strong gun from. Steel for this purpose ought to be free from all impurities, such as phosphorus, sulphur, and silica.

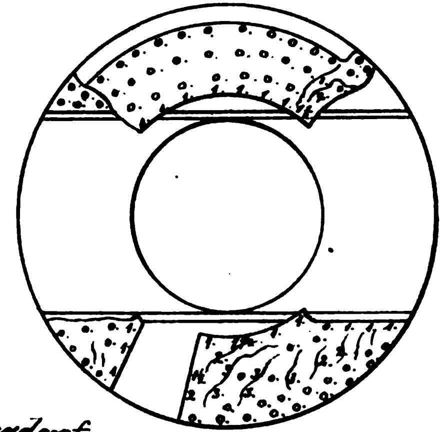
Yours, truly,

A. W. BLACK.

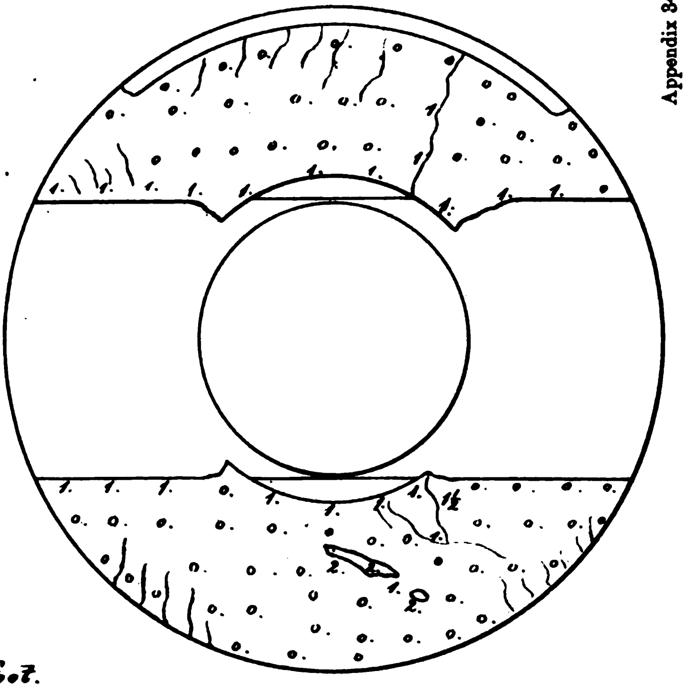
Capt. W. S. STARRING, *New York.*

PLATE I.

8$^{\text{in.}}$ Breech.



11$^{\text{in.}}$ Breech.



Grades of Hardness:

0

1 - annealed tool.

2 = dark-blue temper. 570°.

3 = harder than above.

Scale 1½$^{\text{in.}}$ = 1 foot.

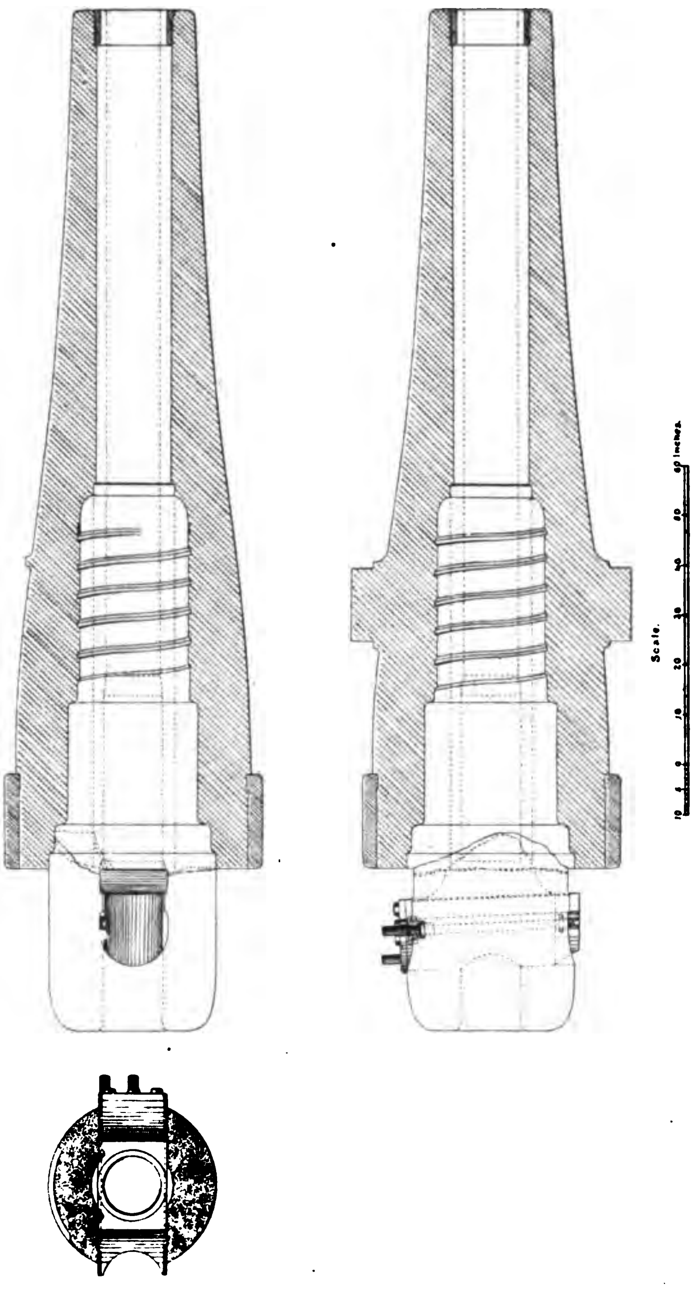
Nov. 16th. 1881.

Appendix 34—1882.

PLATE II.

11 INCH B. L. CHAMBERED RIFLE SHOWING LINES OF FRACTURE ON JACKET.

(GUN No 1)



Appendix 34—1882.

APPENDIX 35.

REPORT ON THE STEEL PARTS OF 11-INCH BREECH-LOADING CHAMBERED RIFLE No. 1.

One Plate.

THE ORDNANCE BOARD, UNITED STATES ARMY,
NEW YORK ARSENAL,
Governor's Island, N. Y. H., March 30, 1882.

SIR: I have the honor to forward physical tests, showing the extension, restoration, and permanent set of twelve steel specimens cut from the ruptured breech receiver of 11-inch breech-loading rifle No. 1, chambered. The nature of the specimens, as shown in the accompanying drawing, is as follows:

Nos. 1 and 7, tangential from interior.
Nos. 2 and 8, tangential from exterior.
Nos. 3 and 4, radial from near ruptured surface.
Nos. 11 and 12, radial from interior.
Nos. 9 and 10, longitudinal from exterior.
Nos. 5 and 6, longitudinal from interior.

These tests are in addition to others previously made and forwarded with report of the Board, of January 16, 1882.

For the Board:

Very respectfully, your obedient servant,

T. G. BAYLOR,
Lieut. Colonel of Ordnance, President of the Board.

CHIEF OF ORDNANCE, U. S. A.,
Washington, D. C.

***Table showing the extension, restoration, and permanent set caused by the undermentioned weights per square inch of area acting upon a solid cylinder of Firth's steel* 3 *inches long and* .563 *inch in diameter, taken from breech receiver of* 11-*inch chambered breech-loading rifle No.* 1 (*after rupture*).**

SPECIMEN MARKED 1.

Weight per square inch of original area.	Extension per inch in length.	Successive extension per inch in length.	Restoration per inch in length.	Successive restoration per inch in length.	Permanent set per inch in length.	Successive permanent set per inch in length.
Pounds.	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
1, 000	0. 000000	0. 000000	0. 000000	0. 000000	0. 000000	0. 000000
2, 000	. 000000	. 000000	. 000000	. 000000	. 000000	. 000000
3, 000	. 000000	. 000000	. 000000	. 000000	. 000000	. 000000
4, 000	. 000333	. 000333	. 000333	. 000333	. 000000	. 000000
5, 000	. 000333	. 000000	. 000333	. 000000	. 000000	. 000000
6, 000	. 000333	. 000000	. 000333	. 000000	. 000000	. 000000
7, 000	. 000333	. 000000	. 000333	. 000000	. 000000	. 000000
8, 000	. 000333	. 000000	. 000333	. 000000	. 000000	. 000000

Table showing the extension, restoration, and permanent set, &c.—**Continued.**

SPECIMEN MARKED 1—Continued.

Weight per square inch of original area.	Extension per inch in length.	Successive extension per inch in length.	Restoration per inch in length.	Successive restoration per inch in length.	Permanent set per inch in length.	Successive permanent set per inch in length.
Pounds.	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
9, 000	.000333	.000000	.000333	.000000	.000000	.000000
10, 000	.000333	.000000	.000333	.000000	.000000	.000000
11, 000	.000333	.000000	.000333	.000000	.000000	.000000
12, 000	.000333	.000000	.000333	.000000	.000000	.000000
13, 000	.000667	.000334	.000667	.000334	.000000	.000000
14, 000	.000667	.000000	.000667	.000000	.000000	.000000
15, 000	.000667	.000000	.000667	.000000	.000000	.000000
16, 000	.000667	.000000	.000667	.000000	.000000	.000000
17, 000	.000667	.000000	.000667	.000000	.000000	.000000
18, 000	.000667	.000000	.000667	.000000	.000000	.000000
19, 000	.000667	.000000	.000667	.000000	.000000	.000000
20, 000	.001333	.000666	.000333	—.000334	.001000	.001000
21, 000	.001667	.000334	.000667	+.000334	.001000	.000000
22, 000	.002333	.000666	.001333	.000666	.001000	.000000
23, 000	.003000	.000667	.001667	.000334	.001333	.000333
24, 000	.003667	.000667	.002667	.001000	.001000	—.000333
25, 000	.004667	.001000	.003667	.001000	.001000	.000000
26, 000	.005333	.000666	.004333	.000667	.001000	.000000
27, 000	.006333	.001000	.005000	.000667	.001333	.000333
28, 000	.007000	.000667	.006000	.001000	.001000	—.000333
29, 000	.008000	.001000	.006667	.000667	.001333	.000333
30, 000	.009000	.001000	.007667	.001000	.001333	.000000
31, 000	.010333	.001333	.009000	0.001333	0.001333	0.000000
32, 000	.011333	.001000	.009667	.000667	.001666	.000333
33, 000	.013000	.002000	.011333	.001667	.001667	.000001
34, 000	.014333	.001333	.012667	.001334	.001666	—.000001
35, 000	.015333	.001000	.013666	.001000	.001666	.000000
36, 000	.016333	.001000	.015000	.001334	.001333	—.000333
37, 000	.017333	.001000	.015666	.000666	.001666	.000333
38, 000	.018667	.001334	.017000	.001334	.001667	—.000001
39, 000	.022000	.003333	.020333	.003333	.001667	.000000
40, 000	.023667	.001667	.021666	.001333	.002001	.000334
41, 000	.025333	.001666	.023000	.001334	.002333	.000332
42, 000	.026333	.001000	.024333	.001333	.002000	—.000333
43, 000	.027667	.001334	.025666	.001333	.002001	+.000001
44, 000	.029667	.002000	.027000	.001334	.002667	.000666
45, 000	.031333	.001666	.029100	.002000	.002333	—.000334
46, 000	.033000	.001667	.031000	.002000	.002000	—.000333
47, 000	.035333	.002333	.033000	.002000	.002332	.000333
48, 000	.038333	.003000	.035667	.002667	.002666	.000333
49, 000	.040333	.002000	.038000	.002333	.002333	—.000333
50, 000	.042667	.002334	.040333	.002333	.002334	.000001
51, 000	.046000	.003333	.042667	.002334	.003333	+.000999
52, 000	.049667	.003667	.047000	.004333	.002667	—.000666
53, 000	.052667	.003000	.049667	.002667	.003000	.000333
54, 000	.055333	.002666	.052333	.002666	.003000	.000000
55, 000	.059333	.004000	.056667	.004334	.002333	—.000667
56, 000	.064000	.004667	.061000	.004333	.003000	.000667
57, 000	.067667	.003667	.064667	.003667	.003000	.000000
58, 000	.074000	.006333	.070667	.006000	.003333	.000333
59, 000	.080333	.006333	.077000	.006333	.003333	.000000
60, 000	.090333	.010000	.087000	.010000	.003333	.000000
61, 000	.095333	.005000	.091667	.004667	.003666	.000336
62, 000	.116333	.021000	.112667	.021000	.003666	.000000
63, 000	.123333	.006000	.123333	.010666	.000000	—.003666
64, 000	(*)	(*)	(*)	(*)	(*)	(*)

* Specimen broke.

GENERAL SUMMARY.

Specific gravity	7.8871
Hardness	10.82
Original area of cross-section ... sq. inch	.2489
Elastic limit ... lbs	19,000
Extension per inch at elastic limit ... inch	0.000667
Ultimate resistance per square inch of original area ... lbs	64,000
Ultimate extension per inch ... inch	0.123333
Ratio of elastic to ultimate resistance	3.37
Contraction in area at fracture ... per cent	43.67
Ultimate resistance per square inch of fractured area ... lbs	113,617
Position of fracture	Near center.
Character of surface	Fibrous.

Table showing the extension, restoration, and permanent set caused by the undermentioned weights per square inch of area acting upon a solid cylinder of Firth's steel 2.93 *inches long and* .559 *inch in diameter, taken from breech receiver of* 11-*inch chambered breech-loading rifle No.* 1 (*after rupture*).

SPECIMEN MARKED 2.

Weight per square inch of original area.	Extension per inch in length.	Successive extension per inch in length.	Restoration per inch in length.	Successive restoration per inch in length.	Permanent set per inch in length.	Successive permanent set per inch in length.
Pounds.	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
1, 000	0. 000000	0. 000000	0. 000000	0. 000000	0. 000000	0. 000000
2, 000	. 000000	. 000000	. 000000	. 000000	. 000000	. 000000
3, 000	. 000000	. 000000	. 000000	. 000000	. 000000	. 000000
4, 000	. 000000	. 000000	. 000000	. 000000	. 000000	. 000000
5, 000	. 000000	. 000000	. 000000	. 000000	. 000000	. 000000
6, 000	. 000000	. 000000	. 000000	. 000000	. 000000	. 000000
7, 000	. 000000	. 000000	. 000000	. 000000	. 000000	. 000000
8, 000	. 000000	. 000000	. 000000	. 000000	. 000000	. 000000
9, 000	. 000000	. 000000	. 000000	. 000000	. 000000	. 000000
10, 000	. 000000	. 000000	. 000000	. 000000	. 000000	. 000000
11, 000	. 000000	. 000000	. 000000	. 000000	. 000000	. 000000
12, 000	. 000000	. 000000	. 000000	. 000000	. 000000	. 000000
13, 000	. 000000	. 000000	. 000000	. 000000	. 000000	. 000000
14, 000	. 000336	. 000336	. 000336	. 000336	. 000000	. 000000
15, 000	. 000671	. 000335	. 000671	. 000335	. 000000	. 000000
16, 000	. 001007	. 000336	. 000336	—. 000335	. 000671	. 000671
17, 000	. 001007	. 000000	. 000336	. 000000	. 000671	. 000000
18, 000	. 001342	. 000335	. 000336	. 000000	. 001006	. 000335
19, 000	. 001342	. 000000	. 000671	. 000335	. 000671	—. 000335
20, 000	. 001678	. 000336	. 000671	. 000000	. 001007	. 000336
21, 000	. 001678	. 000000	. 001007	. 000336	. 000671	—. 000336
22, 000	. 002013	. 000335	. 001342	. 000335	. 000671	. 000000
23, 000	. 002685	. 000672	. 001678	. 000336	. 001007	. 000336
24, 000	. 004027	. 001342	. 002685	. 001007	. 001342	. 000335
25, 000	. 004362	. 000335	. 003691	. 001006	. 000671	. 000671
26, 000	. 005034	. 000672	. 004027	. 000336	. 001007	. 000336
27, 000	. 006040	. 001006	. 004698	. 000671	. 001342	. 000335
28, 000	. 006711	. 000671	. 005705	. 001007	. 001006	—. 000336
29, 000	. 007384	. 000673	. 006376	. 000671	. 001008	—. 000002
30, 000	. 008389	. 001005	. 006711	. 000335	. 001678	. 000670
31, 000	. 009060	. 000671	. 007718	. 001007	. 001342	—. 000336
32, 000	. 010067	. 001007	. 008725	. 001007	. 001342	. 000000
33, 000	. 011409	. 001342	. 009732	. 001007	. 001677	. 000335
34, 000	. 012416	. 001007	. 010738	. 001006	. 001678	. 000001
35, 000	. 013758	. 001342	. 012080	. 001342	. 001678	. 000000
36, 000	. 015101	. 001343	. 013087	. 001007	. 002014	. 000336
37, 000	. 016107	. 001006	. 014094	. 001007	. 002013	—. 000001
38, 000	. 018121	. 002014	. 016107	. 002013	. 002014	. 000001
39, 000	. 018792	. 000671	. 016443	. 000336	. 002349	. 000335
40, 000	. 019128	. 000336	. 017114	. 000671	. 002014	—. 000335
41, 000	. 019799	. 000671	. 017785	. 000671	. 002014	. 000000
42, 000	. 020470	. 000671	. 018456	. 000671	. 002014	. 000000
43, 000	. 021812	. 001342	. 021134	. 001678	. 000678	—. 001336
44, 000	. 023154	. 001342	. 021476	. 001342	. 001678	. 001000
45, 000	. 026174	. 002020	. 024161	. 002685	. 002013	. 000335
46, 000	. 027517	. 001343	. 025503	. 001342	. 002014	. 000001
47, 000	. 029195	. 001678	. 026846	. 001343	. 002349	. 000335
48, 000	. 031208	. 002013	. 028859	. 002013	. 002349	. 000000
49, 000	. 033221	. 002013	. 031208	. 002349	. 002013	—. 000336
50, 000	. 034564	. 001343	. 032886	. 001678	. 001678	—. 000335
51, 000	. 037248	. 002684	. 034564	. 001678	. 002684	. 001006
52, 000	. 039933	. 002685	. 037248	. 002684	. 002685	. 000001
53, 000	. 042617	. 002684	. 040604	. 003356	. 002013	—. 000672
54, 000	. 044966	. 002349	. 041946	. 001342	. 003020	. 001007
55, 000	. 048322	. 003356	. 045973	. 004027	. 002349	—. 000671
58, 000	. 052013	. 003691	. 049329	. 003356	. 002684	. 000335
57, 000	. 056376	. 004363	. 054027	. 004698	. 002349	—. 000335
58, 000	. 060738	. 004362	. 057718	. 003691	. 003020	. 000671
59, 000	. 065772	. 005034	. 062752	. 005034	. 003020	. 000000
60, 000	. 071477	. 005705	. 068456	. 005704	. 003021	. 000001
61, 000	. 080201	. 008724	. 077181	. 008725	. 003020	—. 000001
62, 000	. 085906	. 005705	. 082215	. 005034	. 003691	. 000671
63, 000	. 098322	. 012416	. 094967	. 012752	. 003355	—. 000336
64, 000	. 112085	. 013753	. 108390	. 013423	. 003695	. 000340
65, 000	. 122483	. 010398	. 119127	. 010737	. 003356	—. 000339
66, 000	. 150000	. 027517	. 145973	. 026846	. 004027	. 000671
67, 000	. 221476	. 071474	(*)	(*)	(*)	(*)

* Specimen broke.

Table showing the extension, restoration, and permanent set, &c.—Continued.

GENERAL SUMMARY—SPECIMEN MARKED 2.

Specific gravity	7.8519
Hardness	10.37
Original area of cross-section ... square inch	0.2454
Elastic limit ... pounds	15,000
Extension per inch at elastic limit ... inch	0.000671
Ultimate resistance per square inch of original area ... pounds	67,000
Ultimate extension per inch ... inch	0.221436
Ratio of elastic to ultimate resistance	4.47
Contraction in area at fracture ... per cent	38.87
Ultimate resistance per square inch of fractured area ... pounds	109,545
Position of fracture	near center.
Character of surface	crystalline and fibrous.

Table showing the extension, restoration, and permanent set caused by the undermentioned weights per square inch of area acting upon a solid cylinder of Firth's steel 3 *inches long and* .560 *inch in diameter, taken from breech-receiver of* 11-*inch chambered breech-loading rifle No.* 1 (*after rupture*).

SPECIMEN MARKED 3.

Weight per square inch of original area.	Extension per inch in length.	Successive extension per inch in length.	Restoration per inch in length.	Successive restoration per inch in length.	Permanent set per inch in length.	Successive permanent set per inch in length.
Pounds.	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
1,000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2,000	.000000	.000000	.000000	.000000	.000000	.000000
3,000	.000000	.000000	.000000	.000000	.000000	.000000
4,000	.000000	.000000	.000000	.000000	.000000	.000000
5,000	.000333	.000333	.000333	.000333	.000000	.000000
6,000	.000667	.000334	.000667	.000334	.000000	.000000
7,000	.000667	.000000	.000667	.000000	.000000	.000000
8,000	.000667	.000000	.000667	.000000	.000000	.000000
9,000	.000667	.000000	.000667	.000000	.000000	.000000
10,000	.000667	.000000	.000667	.000000	.000001	.000000
11,000	.000667	.000000	.000667	.000000	.000000	.000000
12,000	.000667	.000000	.000667	.000000	.000000	.000000
13,000	.000667	.000000	.000667	.000000	.000000	.000000
14,000	.000667	.000000	.000333	— .000334	.000334	.000334
15,000	.001000	.000333	.000333	.000000	.000667	.000333
16,000	.001000	.000000	.000333	.000000	.000667	.000000
17,000	.001333	.000333	.000333	.000000	.001000	.000333
18,000	.001333	.000000	.000667	.000334	.000666	— .000334
19,000	.001333	.000000	.000667	.000000	.000666	.000000
20,000	.001667	.000334	.000667	.000000	.001000	.000334
21,000	.002000	.000333	.000667	.000000	.001333	.000333
22,000	.002333	.000333	.001000	.000333	.001333	.000000
23,000	.002667	.000334	.002000	.001000	.000667	— .000666
24,000	.003000	.000333	.002333	.000333	.000667	.000000
25,000	.003667	.000667	.003333	.001000	.000334	— .000333
26,000	.005333	.001666	.004333	.001000	.001000	.000666
27,000	.006333	.001000	.005000	.000667	.001333	.000333
28,000	.007333	.001000	.006333	.001333	.001000	— .000333
29,000	.008000	.000667	.007333	.001000	.000667	.000333
30,000	.008667	.000667	.007333	.000000	.001334	.000667
31,000	.009333	.000666	.008333	.001000	.001000	— .000334
32,000	.010333	.001000	.009333	.001000	.001000	.000000
33,000	.010667	.000334	.009667	.000334	.001000	.000000
34,000	.012667	.002000	.011333	.001666	.001334	.000334
35,000	.013667	.001000	.012000	.000667	.001667	.000333
36,000	.014333	.000666	.013000	.001000	.001333	— .000334
37,000	.016667	.002334	.014667	.001667	.002000	.000667
38,000	.017333	.000666	.015667	.001000	.001666	— .000334
39,000	.018667	.001334	.017000	.001333	.001667	.000001
40,000	.019333	.000666	.018000	.001000	.001333	— .000334
41,000	.020333	.001000	.018667	.000667	.001666	.000333
42,000	.022000	.001667	.020000	.001333	.002000	.000334
43,000	.024667	.002667	.023333	.003333	.001334	— .000666
44,000	.026333	.001666	.024333	.001000	.002000	.000666
45,000	.027333	.001000	.025333	.001000	.002000	.000000
46,000	.029333	.002000	.027333	.002000	.002000	.000000
47,000	.032333	.003000	.030333	.003000	.002000	.000000
48,000	.033667	.001334	.031333	.001000	.002334	.000334
49,000	.035333	.001666	.033000	.001667	.002333	— .000001
50,000	.040333	.005000	.037667	.004667	.002666	.000333

Table showing the extension, restoration, and permanent set, &c.—Continued.

SPECIMEN MARKED 3—Contnued.

Weight per square inch of original area.	Extension per inch in length.	Successive extension per inch in length.	Restoration per inch in length.	Successive restoration per inch in length.	Permanent set per inch in length.	Successive permanent set per inch in length.
Pounds.	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
51, 000	. 041667	. 001334	. 039333	. 001666	. 002334	— . 000332
52, 000	. 044667	. 003000	. 042333	. 003000	. 002334	. 000000
53, 000	. 048000	. 003333	. 045333	. 003000	. 002667	. 000333
54, 000	. 009667	. 001667	. 047333	. 002000	. 002334	— . 000333
55, 000	. 053333	. 003666	. 050667	. 003334	. 002666	. 000332
56, 000	. 059333	. 006000	. 056667	. 006000	. 002666	. 000000
57, 000	. 061000	. 001667	. 058667	. 002000	. 002333	— . 000333
58, 000	. 068000	. 007000	. 064667	. 006000	. 003333	. 001000
59, 000	. 074667	. 006667	. 071667	. 007000	. 003000	— . 000333
60, 000	. 081000	. 006333	. 078000	. 006333	. 003000	. 000000
61, 000	. 088333.	. 007333	. 085000	. 007000	. 003333	. 000333
62, 000	. 097000	. 008667	. 093667	. 008667	. 003333	. 000000
63, 000	. 107000	. 010000	. 103667	. 010000	. 003333	. 000000
64, 000	. 122667	. 015667	. 118667	. 015000	. 004000	. 000667
65, 000	. 142333	. 019666	. 138667	. 020000	. 003666	— . 000334
66, 000	. 239000	. 096667	(*)	(*)	(*)	(*)

* Specimen broke.

GENERAL SUMMARY.

Specific gravity	7. 8600
Hardness	10. 37
Original area of cross-section . sq. inch..	0. 2463
Elastic limit ..... pounds..	13, 000
Extension per inch at elastic limit . in..	0. 000667
Ultimate resistance per square inch of original area ..... pounds..	66, 000
Ultimate extension per inch ...... inch..	0. 239000
Ratio of elastic to ultimate resistance...	4. 62
Contraction in area at fracture . per cent..	41. 86
Ultimate resistance per square inch of fractured area ..... pounds..	113, 512
Position of fracture	near center.
Character of surface	crystalline and fibrous.

Table showing the extension, restoration, and permanent set caused by the undermentioned weights per square inch of area acting upon a solid cylinder of Firth's steel, 2.976 *inches long and* .564 *inch in diameter, taken from breech-receiver of* 11-*inch chambered breech-loading rifle No.* 1 (*after rupture*).

SPECIMEN MARKED 4.

Weight per square inch of original area.	Extension per inch in length.	Successive extension per inch in length.	Restoration per inch in length.	Successive restoration per inch in length.	Permanent set per inch in length.	Successive permanent set per inch in length.
Pounds.	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
1, 000	0. 000000	0. 000000	0. 000000	0. 000000	0. 000000	0. 000000
2, 000	. 000000	. 000000	. 000000	. 000000	. 000000	. 000000
3, 000	. 000000	. 000000	. 000000	. 000000	. 000000	. 000000
4, 000	. 000336	. 000336	. 000336	. 000336	. 000000	. 000000
5, 000	. 000672	. 000336	. 000672	. 000336	. 000000	. 000000
6, 000	. 000672	. 000000	. 000672	. 000000	. 000000	. 000000
7, 000	. 000672	. 000000	. 000672	. 000000	. 000000	. 000000
8, 000	. 000672	. 000000	. 000672	. 000000	. 000000	. 000000
9, 000	. 000672	. 000000	. 000672	. 000000	. 000000	. 000000
10. 000	. 001008	. 000336	. 001008	. 000336	. 000000	. 000000
11, 000	. 001008	. 000000	. 001008	. 000000	. 000000	. 000000
12, 000	. 001344	. 000336	. 001344	. 000336	. 000000	. 000000
13, 000	. 001344	. 000000	. 001344	. 000000	. 000000	. 000000
14, 000	. 001344	. 000000	. 001344	. 000000	. 000000	. 000000
15, 000	. 001344	. 000000	. 001344	. 000000	. 000000	. 000000
16, 000	. 001344	. 000000	. 001344	. 000000	. 000000	. 000000

Table showing the extension, restoration, and permanent set, &c.—Continued.

SPECIMEN MARKED 4—Continued.

Weight per square inch of original area.	*Extension per inch in length.	Successive extension per inch in length.	Restoration per inch in length.	Successive restoration per inch in length.	Permanent set per inch in length.	Successive permanent set per inch in length.
Pounds.	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
17, 000	.001344	.000000	.000672	— .000672	.000672	.000672
18, 000	.001680	.000336	.000672	.000000	.001008	.000336
19, 000	.001680	.000000	.000672	.000000	.001008	.000000
20, 000	.002016	.000336	.001344	.000672	.000672	— .000336
21, 000	.002352	.000336	.001680	.000336	.000672	.000000
22, 000	.003024	.000672	.002352	.000672	.000672	.000000
23, 000	.003360	.000336	.002352	.000000	.001008	.000336
24, 000	.004704	.001344	.003360	.001008	.001344	.000336
25, 000	.005040	.000336	.004704	.001344	.000336	— .001008
26, 000	.005376	.000336	.005040	.000336	.000336	.000000
27, 000	.005712	.000336	.005040	.000000	.000672	.000336
28, 000	.006384	.000672	.005376	.000336	.001008	.000336
29, 000	.007392	.001008	.006384	.001008	.001008	.000000
30, 000	.008401	.001009	.007392	.001008	.001009	.000001
31, 000	.009745	.001344	.008401	.001009	.001344	.000335
32, 000	.010417	.000672	.009409	.001008	.001008	— .000336
33, 000	.012097	.001680	.010417	.001008	.001680	.000672
34, 000	.013441	.001344	.011424	.001007	.002017	.000337
35, 000	.014113	.000672	.012433	.001009	.001680	— .000337
36, 000	.014785	.000672	.013441	.001008	.001344	— .000336
37, 000	.016129	.001344	.014785	.001344	.001344	.000000
38, 000	.017809	.001680	.016465	.001680	.001344	.000000
39, 000	.019489	.001680	.017809	.001344	.001680	.000336
40, 000	.020497	.001008	.018481	.000672	.002016	.000336
41, 000	.022513	.002016	.021169	.002688	.001344	— .000672
42, 000	.023858	.001345	.021841	.000672	.002017	.000673
43, 000	.026546	.002688	.024866	.003025	.001680	— .000337
44, 000	.028226	.001680	.025874	.001008	.002352	.000672
45, 000	.030242	.002016	.028226	.002352	.002016	— .000336
46, 000	.031922	.001680	.029570	.001344	.002352	.000336
47, 000	.034611	.002689	.032258	.002682	.002353	.000001
48, 000	.036626	.002015	.034274	.002016	.002352	— .000001
49, 000	.038979	.002353	.036626	.002352	.002353	.000001
50, 000	.041668	.002689	.038979	.002353	.002689	.000336
51, 000	.044019	.002351	.041668	.002689	.002351	— .000338
52, 000	.046035	.002016	.042676	.001008	.003359	.001008
53, 000	.052083	.006048	.049731	.007055	.002352	— .001007
54, 000	.055444	.003361	.052419	.002688	.003025	.000673
55, 000	.061828	.006384	.058804	.006385	.003024	— .000001
56, 000	.064518	.002690	.061828	.003024	.002690	— .000334
57, 000	.066868	.002350	.063844	.002016	.003024	.000334
58, 000	.075605	.008737	.072917	.009073	.002688	— .000336
59, 000	.087030	.011425	.083334	.010417	.003696	.001008
60, 000	.092070	.005040	.088710	.005376	.003360	— .000336
61, 000	.105511	.013441	.101479	.012769	.004032	.000672
62, 000	.113240	.007739	.108871	.007392	.004369	.000337
63, 000	.115592	.002352	.112232	.003361	.003360	— .001009
64, 000	.155242	.036750	.151210	.038978	.004032	.000672
65, 000	.238239	.082997	(*)	(*)	(*)	(*)

*Specimen broke.

GENERAL SUMMARY.

Specific gravity		7. 861
Hardness		10. 37
Original area of cross-section	square inch..	.1496
Elastic limit	pounds..	16, 000
Extension per inch at elastic limit	inch..	0. 001344
Ultimate resistance per square inch of original area	pounds..	65, 000
Ultimate extension per inch	inch..	0. 238239
Ratio of elastic to ultimate resistance	inches..	4. 06
Contraction in area at fracture	per cent..	36. 35
Ultimate resistance per square inch of fractured area	pounds..	103, 386
Position of fracture		near center.
Character of surface		fibrous and crystalline.

Table showing the extension, restoration, and permanent set caused by the undermentioned weights per square inch of the primitive section acting upon a solid cylinder of Firth's steel 2.996 *inches long and* .562 *inch in diameter, taken from breech receiver of* 11-*inch chambered breech-l ading rifle No.* 1 (*after rupture*).

SPECIMEN MARKED 5.

Weight per square inch of original area.	Extension per inch in length.	Successive extension per inch in length.	Restoration per inch in length.	Successive restoration per inch in length.	Permanent set per inch in length.	Successive permanent set per inch in length.
Pounds.	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
1,000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
2,000	.000000	.000000	.000000	.000000	.000000	.000000
3,000	.000334	.000334	.000334	.000334	.000000	.000000
4,000	.000334	.000000	.000334	.000000	.000000	.000000
5,000	.000334	.000000	.000334	.000000	.000000	.000000
6,000	.000334	.000000	.000334	.000000	.000000	.000000
7,000	.000334	.000000	.000334	.000000	.000000	.000000
8,000	.000334	.000000	.000334	.000000	.000000	.000000
9,000	.000668	.000334	.000668	.000334	.000000	.000000
10,000	.000668	.000000	.000668	.000000	.000000	.000000
11,000	.000668	.000000	.000668	.000000	.000000	.000000
12,000	.000668	.000000	.000668	.000000	.000000	.000000
13,000	.000668	.000000	.000668	.000000	.000000	.000000
14,000	.000668	.000000	.000668	.000000	.000000	.000000
15,000	.000668	.000000	.000668	.000000	.000000	.000000
16,000	.000668	.000000	.000668	.000000	.000000	.000000
17,000	.001001	.000333	.001001	.000333	.000000	.000000
18,000	.001001	.000000	.001001	.000000	.000000	.000000
19,000	.001001	.000000	.000334	— .000667	.000667	.000667
20,000	.001335	.000334	.000334	.000900	.001001	.000334
21,000	.001668	.000333	.000668	.000334	.001000	— .000001
22,000	.002003	.000335	.001001	.000333	.001002	.000002
23,000	.002336	.000333	.001668	.000667	.000668	— .000334
24,000	.003672	.001336	.002670	.001002	.001002	.000334
25,000	.004339	.000667	.003338	.000668	.001001	— .000001
26,000	.005007	.000668	.004005	.000667	.001002	.000001
27,000	.005674	.000667	.005007	.001002	.000667	— .000335
28,000	.006675	.001001	.005674	.000667	.001001	.000334
29,000	.007343	.000668	.006008	.000334	.001335	.000334
30,000	.008344	.001001	.007009	.001001	.001335	.000000
31,000	.009346	.001002	.008011	.001002	.001335	.000000
32,000	.010347	.001001	.009012	.001001	.001335	.000000
33,000	.011348	.001001	.010014	.001002	.001334	— .000001
34,000	.012350	.001002	.010681	.000667	.001669	.000335
35,000	.013351	.001001	.011682	.001001	.001669	.000000
36,000	.015020	.001669	.013685	.002003	.001335	.000334
37,000	.016021	.001001	.014686	.001001	.001335	.000000
38,000	.018358	.002337	.017023	.002337	.001335	.000000
39,000	.019359	.001001	.017690	.000667	.001669	.000334
40,000	.019693	.000336	.018024	.000334	.001669	.000000
41,000	.022030	.002337	.0020694	.002670	.001336	— .000333
42,000	.023031	.001001	.0021696	.001002	.001335	— .000001
43,000	.024032	.001001	.022363	.000667	.001669	.000334
44,000	.025701	.001669	.023698	.001335	.002003	.000334
45,000	.027704	.002003	.025367	.001669	.002337	.000334
46,000	.029706	.002002	.027704	.002337	.002002	— .000335
47,000	.032043	.002337	.029706	.002002	.002337	.000335
48,000	.033712	.001669	.031709	.002003	.002003	— .000334
49,000	.035381	.001669	.033044	.001335	.002337	.000334
50,000	.039052	.003671	.036716	.003672	.002336	— .000001
51,000	.041722	.002670	.039052	.002336	.002670	.000334
52,000	.044392	.002670	.041722	.001670	.002670	.000000
53,000	.046729	.002337	.044059	.002337	.002670	.000000
54,000	.052403	.005676	.049733	.005674	.002670	.000000
55,000	.055741	.003338	.054406	.004673	.001335	— .001335
56,000	.058077	.002336	.055407	.001001	.002670	.001335
57,000	.065087	.007010	.062083	.006676	.003004	.000334
58,000	.069426	.004339	.066756	.004673	.002670	— .000334
59,000	.074433	.005007	.071095	.004339	.003338	.000668
60,000	.082443	.008010	.077770	.006675	.004673	.001335
61,000	.090454	.008011	.087116	.0090346	.003338	— .001335
62,000	.096462	.006008	.092790	.005674	.003672	.000336
63,000	.111148	.014686	.107810	.005020	.003338	— .000334
64,000	.130507	.019359	.126501	.018691	.004006	.000668
65,000	.155876	.025369	.151869	.025368	.004007	.000001
66,000	.266789	.110913	(*)	(*)	(*)	(*)

* Broke.

Table showing the extension, restoration, and permanent set, &c.—Continued.

GENERAL SUMMARY—SPECIMEN MARKED 5.

Specific gravity	7.8566
Hardness	10.00
Original area of cross-section ... square inch..	.248
Elastic limit ... pounds..	18,000
Extension per inch at elastic limit ... inch..	0.001001
Ultimate resistance per square inch of original area ... pounds..	66,000
Ultimate extension per inch ... inch..	0.266789
Ratio of elastic to ultimate resistance	3.66
Contraction in area at fracture ... per cent..	37.58
Ultimate resistance per square inch of fractured area ... pounds..	105,738
Position of fracture	near center.
Character of surface	fibrous.

Table showing the extension, restoration, and permanent set caused by the undermentioned weights per square inch of the primitive section acting upon a solid cylinder of Firth's steel 2.993 *inches long and* .563 *inches in diameter, taken from breech receiver of* 11-*inch chambered breech-loading rifle No.* 1 (*after rupture*).

SPECIMEN MARKED 6.

Weight per square inch of original area.	Extension per inch in length.	Successive extension per inch in length.	Restoration per inch in length.	Successive restoration per inch in length.	Permanent set per inch in length.	Successive permanent set per inch in length.
Pounds.	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
1,000	0.000334	0.000334	0.000334	0.000334	0.000000	0.000000
2,000	.000334	.000000	.000334	.000000	.000000	.000000
3,000	.000334	.000000	.000334	.000000	.000000	.000000
4,000	.000668	.000334	.000334	.000000	.000334	.000334
5,000	.000668	.000000	.000334	.000000	.000334	.000000
6,000	.000668	.000000	.000334	.000000	.000334	.000000
7,000	.000668	.000000	.000334	.000000	.000334	.000000
8,000	.000668	.000000	.000334	.000000	.000334	.000000
9,000	.001002	.000334	.000334	.000000	.000668	.000334
10,000	.001002	.000000	.000334	.000000	.000668	.000000
11,000	.000002	.000000	.000334	.000000	.000668	.000000
12,000	.001002	.000000	.000334	.000000	.000668	.000000
13,000	.001336	.000334	.000668	.000334	.000668	.000000
14,000	.001336	.000000	.000668	.000000	.000668	.000000
15,000	.001336	.000000	.000668	.000000	.000668	.000000
16,000	.001336	.000000	.000668	.000000	.000668	.000000
17,000	.001336	.000000	.000668	.000000	.000668	.000000
18,000	.001336	.000000	.000668	.000000	.000668	.000000
19,000	.001336	.000000	.000668	.000000	.000668	.000000
20,000	.001336	.000000	.000668	.000000	.000668	.000000
21,000	.001671	.000335	.000668	.000000	.001003	.000335
22,000	.001671	.000000	.001002	.000334	.000669	— .000334
23,000	.001671	.000000	.001002	.000000	.000669	.000000
24,000	.002673	.001002	.002005	.001003	.000668	— .000001
25,000	.003341	.000668	.002673	.000668	.000668	.000000
26,000	.004009	.000668	.003341	.000668	.000668	.000000
27,000	.004678	.000669	.004009	.000668	.000669	.000001
28,000	.005346	.000668	.004343	.000334	.001003	.000334
29,000	.008353	.003007	.007016	.002673	.001337	.000334
30,000	.008687	.000336	.007350	.000334	.001337	.000000
31,000	.009021	.000334	.007685	.000335	.000336	— .000001
32,000	.009689	.000668	.008353	.000668	.001336	.001000
33,000	.010692	.001003	.009021	.000668	.001671	.000335
34,000	.011026	.000334	.010023	.001002	.001003	— .000668
35,000	.012362	.001336	.010692	.000669	.001670	.000667
36,000	.013365	.001003	.011694	.001002	.001671	.000001
37,000	.015369	.002004	.013365	.001671	.002004	.000333
38,000	.016371	.001002	.013699	.000334	.002672	.000668
39,000	.017374	.001003	.016037	.002338	.001337	— .001335
40,000	.09044	.001670	.017040	.001003	.002004	.000667
41,000	.020047	.001003	.018041	.001001	.002006	.000002
42,000	.020715	.000668	.018710	.000669	.002005	— .000001
43,000	.022386	.001671	.020381	.001671	.002005	.000000
44,000	.023722	.001336	.021717	.001336	.002005	.000000
45,000	.026729	.003007	.024724	.003007	.002005	.000000
46,000	.027397	.000668	.025393	.000669	.002004	— .000001
47,000	.028734	.001337	.026729	.001336	.002005	.000001
48,000	.029736	.001002	.028065	.001336	.001671	— .000334

Table showing the extension, restoration, and permanent set, &c.—Continued.

SPECIMEN MARKED 6—Continued.

Weight per square inch of original area.	Extension per inch in length.	Successive extension per inch in length.	Restoration per inch in length.	Successive restoration per inch in length.	Permanent set per inch in length.	Successive permanent set per inch in length.
Pounds.	*Inch*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
49, 000	.032743	.003007	.030738	.002673	.002005	.000334
50, 000	.034080	.001337	.032074	.001336	.002006	.000001
51, 000	.039759	.005679	.037421	.005347	.002338	.000332
52, 000	.041430	.001671	.038757	.001336	.002673	.000335
53, 000	.044103	.002673	.041764	.003007	.002337	— .000334
54, 000	.045429	.001336	.043101	.001337	.002338	.000001
55, 000	.046775	.001336	.045105	.002004	.001670	— .000668
56, 000	.052456	.005681	.049783	.004678	.002673	.001003
57, 000	.054795	.002339	.052122	.002339	.002673	.000000
58, 000	.057467	.002672	.054795	.002673	.002672	— .000001
59, 000	.065152	.007685	.062145	.008350	.003007	.000335
60, 000	.067825	.002673	.065152	.003007	.002673	— .000334
61, 000	.074842	.007017	.071500	.006348	.003342	.000669
62, 000	.078517	.003675	.075175	.003675	.003342	.000000
63, 000	.085867	.007350	.082860	.006685	.003007	— .000335
64, 000	.086869	.001002	....	....	....	....

GENERAL SUMMARY.

Specific gravity	7. 8662
Hardness	10. 82
Original area of cross-section .... square inch..	.2489
Elastic limit .... pounds..	12, 000
Extension per inch at elastic limit .... inch..	0. 001002
Ultimate resistance per square inch of original area .... pounds..	64, 000
Ultimate extension per inch .... inch..	0. 086869
Ratio of elastic to ultimate resistance	5. 33
Contraction in area at fracture .... per cent..	7. 59
Ultimate resistance per square inch of fractured area .... pounds..	69, 562
Position of fracture	near center
Character of surface	crystalline

Table showing the extension, restoration, and permanent set caused by the undermentioned weights per square inch of the primitive section acting upon a solid cylinder of Firth's steel, 3 *inches long and* .562 *inch in diameter, taken from breech-receiver of* 11-*inch chambered breech-loading rifle No.* 1 (*after rupture*).

SPECIMEN MARKED 7.

Weight per square inch of original area.	Extension per inch in length.	Successive extension per inch in length.	Restoration per inch in length.	Successive restoration per inch in length.	Permanent set per inch in length.	Successive permanent set per inch in length.
Pounds.	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
1, 000	.000000	.000000	.000000	.000000	.000000	.000000
2, 000	.000000	.000000	.000000	.000000	.000000	.000000
3, 000	.000000	.000000	.000000	.000000	.000000	.000000
4, 000	.000333	.000333	.000333	.000333	.000000	.000000
5, 000	.000333	.000000	.000333	.000000	.000000	.000000
6, 000	.000333	.000000	.000333	.000000	.000000	.000000
7, 000	.000667	.000334	.000667	.000334	.000000	.000000
8, 000	.000667	.000000	.000667	.000000	.000000	.000000
9, 000	.000667	.000000	.000667	.000000	.000000	.000000
10, 000	.000667	.000000	.000667	.000000	.000000	.000000
11, 000	.000667	.000000	.000333	—.000334	.000334	.000334
12, 000	.000667	.000000	.000333	.000000	.000334	.000000
13, 000	.000667	.000000	.000333	.000000	.000334	.000000
14, 000	.000667	.000000	.000333	.000000	.000334	.000000
15, 000	.000667	.000000	.000333	.000000	.000334	.000000
16, 000	.000667	.000000	.000333	.000000	.000334	.000000

Table showing the extension, restoration, and permanent set, &c.—Continued.

SPECIMEN MARKED 7—Continued.

Weight per square inch of original area.	Extension per inch in length.	Successive extension per inch in length.	Restoration per inch in length.	Successive restoration per inch in length.	Permanent set per inch in length.	Successive permanent set per inch in length.
Pounds.	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
17,000	.000667	.000000	.000333	.000000	.000334	.000000
18,000	.000667	.000000	.000333	.000000	.000334	.000000
19,000	.000667	.000000	.000333	.000000	.000334	.000000
20,000	.000667	.000000	.000333	.000000	.000334	.000000
21,000	.000667	.000000	.000333	.000000	.000334	.000000
22,000	.001000	.000333	.000667	.000334	.000333	—.000001
23,000	.001667	.000667	.001333	.000666	.000334	.000001
24,000	.002333	.000666	.001667	.000334	.000666	.000332
25,000	.003000	.000667	.002333	.000666	.000667	.000001
26,000	.003333	.000333	.003000	.000667	.000333	—.000334
27,000	.004000	.000667	.003333	.000333	.000667	.000334
28,000	.005667	.001667	.005333	.002000	.000334	—.000333
29,000	.006333	.000666	.005667	.000334	.000666	.000332
30,000	.006999	.000666	.006333	.000666	.000666	.000000
31,000	.009333	.002334	.008000	.001667	.001333	.000667
32,000	.009667	.000334	.009000	.001000	.000667	—.000666
33,000	.010667	.001000	.009667	.000667	.001000	.000333
34,000	.011667	.001000	.010333	.000666	.001334	.000334
35,000	.013000	.001333	.012333	.002000	.000667	—.000667
36,000	.014333	.001333	.013000	.001667	.001333	.000666
37,000	.015000	.000667	.014000	.001000	.001000	—.000333
38,000	.017666	.002666	.016333	.002333	.001333	.000333
39,000	.018333	.000667	.017333	.001000	.001000	—.000333
40,000	.019333	.001000	.018333	.001000	.001000	.000000
41,000	.021000	.001667	.019667	.001334	.001333	.000333
42,000	.023000	.002000	.021667	.002000	.001333	.000000
43,000	.024333	.001333	.023000	.001333	.001333	.000000
44,000	.025667	.001334	.023000	.000000	.002667	.001334
45,000	.028667	.003000	.027333	.004333	.001334	—.001333
46,000	.031667	.003000	.030000	.002667	.001667	.000333
47,000	.033000	.001333	.031333	.001333	.001667	.000000
48,000	.034666	.001667	.033000	.001667	.001667	.000000
49,000	.038000	.003333	.036000	.003000	.002000	.000333
50,000	.041000	.003000	.039333	.003333	.001667	—.000333
51,000	.043667	.002667	.042000	.002667	.001667	.000000
52,000	.045667	.002000	.044000	.002000	.001667	.000000
53,000	.050667	.005000	.048333	.004333	.002334	.000667
54,000	.054667	.004000	.053000	.004667	.001667	—.000667
55,000	.059667	.005000	.057667	.004667	.002000	+.000333
56,000	.062333	.002666	.060333	.002666	.002000	.000000
57,000	.069333	.007000	.067667	.007334	.001666	—.000334
58,000	.075667	.006334	.073000	.005333	.002667	.001001
59,000	.080000	.004333	.077667	.004667	.002333	—.000334
60,000	.088667	.008667	.086333	.008666	.002334	+.000001
61,000	.098333	.009666	.096000	.009667	.002333	—.000001
62,000	.109000	.010667	.106333	.010333	.002667	.000334
63,000	.134333	.025333	.131333	.025000	.003000	.000333
64,000	.152000	.017667	.148667	.017334	.003333	.000333
65,000	.258667	.106667	(*)	(*)	(*)	(*)

* Specimen broke.

GENERAL SUMMARY.

Specific gravity	7.8581
Hardness	10.83
Original area of cross-section ... square inch..	0.348
Elastic limit ... pounds..	16,000
Extension per inch at elastic limit ... inch..	0.000667
Ultimate resistance per square inch of original area ... pounds..	65,000
Ultimate extension per inch ... inch..	0.258667
Ratio of elastic to ultimate resistance	6.50
Contraction in area at fracture ... per cent..	27.82
Ultimate resistance per square inch of fractured area ... pounds..	90,065
Position of fracture	near center.
Character of surface	crystalline and fibrous, mixed.

Table showing the extension, restoration, and permanent set caused by the undermentioned weights per square inch of the primitive section acting upon a solid cylinder of Firth's steel, 2.999 inches long and .563 inch in diameter, taken from breech receiver of 11-inch chambered breech-loading rifle No. 1 (after rupture).

SPECIMEN MARKED 8.

Weight per square inch of original area.	Extension per inch in length.	Successive extension per inch in length.	Restoration per inch in length.	Successive restoration per inch in length.	Permanent set per inch in length.	Successive permanent set per inch in length.
Pounds.	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
1,000	.000000	.000000	.000000	.000000	.000000	.000000
2,000	.000000	.000000	.000000	.000000	.000000	.000000
3,000	.000000	.000000	.000000	.000000	.000000	.000000
4,000	.000333	.000333	.000333	.000333	.000000	.000000
5,000	.000333	.000000	.000333	.000000	.000000	.000000
6,000	.000667	.000334	.000667	.000334	.000000	.000000
7,000	.000667	.000000	.090667	.000000	.000000	.000000
8,000	.000667	.000000	.000667	.000000	.000000	.000000
9,000	.000667	.000000	.000667	.000000	.000000	.000000
10,000	.000667	.000000	.000667	.000000	.000000	.000000
11,000	.000667	.000000	.000667	.000000	.000000	.000000
12,000	.000667	.000000	.000667	.000000	.000000	.000000
13,000	.001000	.000333	.000333	−.000334	.000667	.000667
14,000	.001000	.000000	.000333	.000000	.000667	.000000
15,000	.001000	.000000	.000333	.000000	.000667	.000000
16,000	.001000	.000000	.000333	.000000	.000667	.000000
17,000	.001000	.000000	.000333	.000000	.000667	.000000
18,000	.001000	.000000	.000333	.000000	.000667	.000000
19,000	.001333	.000333	.000667	.000334	.000666	−.000001
20,000	.001668	.000335	.000667	.000000	.001001	.000335
21,000	.002000	.000333	.001000	.000333	.001000	−.000001
22,000	.002334	.000334	.001668	.000668	.090666	−.000334
23,000	.002667	.000333	.002000	.000332	.000667	.000001
24,000	.003668	.001001	.002667	.000667	.001001	.000334
25,000	.004668	.001000	.003334	.000667	.001334	.000333
26,000	.005002	.000334	.004001	.000667	.001001	−.000333
27,000	.005335	.000333	.004335	.000334	.001000	−.000001
28,000	.006335	.001000	.005335	.001000	.001000	.000000
29,000	.007669	.001334	.006669	.001334	.001000	.000000
30,000	.008336	.000667	.007002	.000333	.001334	.000334
31,000	.010336	.002000	.008669	.001667	.001667	.000333
32,000	.011670	.001334	.010670	.002001	.001000	.000667
33,000	.012337	.000667	.011004	.000334	.001333	.000333
34,000	.012671	.000334	.011337	.000333	.001334	.000001
35,000	.014005	.001334	.012337	.001000	.001668	.000334
36,000	.015005	.001000	.013338	.001001	.001667	−.000001
37,000	.016672	.001667	.015338	.002000	.001334	−.000333
38,000	.018006	.001334	.016339	.001001	.001667	.000333
39,000	.019673	.001667	.018206	.001667	.001667	.000000
40,000	.025008	.005335	.022674	.004668	.002334	.000667
41,000	.025342	.000334	.023008	.000334	.002334	.000000
42,000	.026008	.000666	.023674	.000666	.002334	.000600
43,000	.027009	.001001	.024675	.001001	.002334	.000000
44,000	.028676	.001667	.026676	.002001	.002000	−.000334
45,000	.031010	.002334	.028343	.001588	.002667	.000667
46,000	.032677	.001667	.031344	.003001	.001333	−.001334
47,000	.035012	.002335	.032344	.001000	.002668	.001335
48,000	.036678	.001666	.034678	.002334	.002000	−.000668
49,000	.040013	.003335	.037679	.003001	.002334	.000334
50,000	.042347	.002334	.039680	.002001	.002667	.000333
51,000	.044015	.001668	.041680	.002000	.002335	−.000332
52,000	.046682	.002667	.044015	.002335	.602667	.000332
53,000	.050017	.003335	.046682	.002667	.003335	.000668
54,000	.056352	.006335	.053684	.007002	.002668	−.000667
55,000	.058353	.002001	.055685	.002001	.002668	.000000
56,000	.061020	.002667	.058019	.002334	.003001	.000333
57,000	.068690	.007670	.065688	.007669	.003002	.000001
58,000	.072024	.003334	.069023	.003335	.003001	−.000001
59,009	.088029	.016005	.076692	.007669	.002337	.000336
60,000	.088696	.000667	.085361	.008669	.003335	−.000998
61,000	.099033	.010337	.095698	.010337	.003335	.000000
62,000	.111037	.012004	.107369	.011671	.003668	.000333
63,000	.121707	.010670	.118039	.010670	.003668	.000000
64,000	.149716	.028009	.145715	.027676	.004001	.000333
65,000	.176059	.026343	(*)	(*)	(*)	(*)

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* Specimen broke.

GENERAL SUMMARY.

Specific gravity	7.872
Hardness	10.37
Original area of cross-section ... square inch..	0.2480
Elastic limit ... pounds..	12,000
Extension per inch at elastic limit ... inch..	0.00067
Ultimate resistance per square inch of original area ... pounds..	65,000
Ultimate extension per inch ... inch..	0.17063
Ratio of elastic to ultimate resistance	5.44
Contraction in area at fracture ... per cent..	42.76
Ultimate resistance per square inch of fractured area ... pounds..	115,642
Position of fracture	near center.
Character of surface	fibrous.

Table showing the extension, restoration, and permanent set caused by the undermentioned weights per square inch of the primitive section acting upon a solid cylinder of Firth's steel 3.004 *inches long and* .562 *inches in diameter, taken from breech-receiver of* 11-*inch chambered breech-loading rifle No.* 1 (*after rupture*).

SPECIMEN MARKED 9.

Weight per square inch of original area.	Extension per inch in length.	Successive extension per inch in length.	Restoration per inch in length.	Successive restoration per inch in length.	Permanent set per inch in length.	Successive permanent set per inch in length.
Pounds.	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
1,000	.000000	.000000	.000000	.000000	.000000	.000000
2,000	.000000	.000000	.000000	.000000	.000000	.000000
3,000	.000000	.000000	.000000	.000000	.000000	.000000
4,000	.000000	.000000	.000000	.000000	.000000	.000000
5,000	.000000	.000000	.000000	.000000	.000000	.000000
6,000	.000333	.000333	.000333	.000333	.000000	.000000
7,000	.000333	.000000	.000333	.000000	.000000	.000000
8,000	.000333	.000000	.000333	.000000	.000000	.000000
9,000	.000333	.000000	.000333	.000000	.000000	.000000
10,000	.000333	.000000	.000333	.000000	.000000	.000000
11,000	.000333	.000000	.000333	.000000	.000000	.000000
12,000	.000333	.000000	.000333	.000000	.000000	.000000
13,000	.000667	.000334	.000667	.000334	.000000	.000000
14,000	.000667	.000000	.000667	.000000	.000000	.000000
15,000	.000667	.000000	.000667	.000000	.000000	.000000
16,000	.000667	.000000	.000667	.000000	.000000	.000000
17,000	.000667	.000000	.000667	.000000	.000000	.000000
18,000	.000667	.000000	.000667	.000000	.000000	.000000
19,000	.000667	.000000	.000667	.000000	.000000	.000000
20,000	.000999	.000332	.000999	.000332	.000000	.000000
21,000	.001332	.000333	.000333	.000666	.000999	.000999
22,000	.001664	.000332	.000666	.000333	.000998	— .000001
23,000	.001664	.000000	.000666	.000000	.000998	.000000
24,000	.002330	.000666	.001332	.000666	.000998	.000000
25,000	.002630	.000300	.001664	.000332	.000966	— .000032
26,000	.002996	.000366	.002330	.000666	.000666	.000300
27,000	.003329	.000333	.002330	.000000	.000999	.000333
28,000	.004993	.001664	.003662	.001332	.001331	.000332
29,000	.006658	.001665	.005326	.001664	.001332	.000001
30,000	.006991	.000333	.005659	.000333	.001332	.000000
31,000	.007989	.000998	.006658	.000999	.001331	— .000001
32,000	.008655	.000666	.007323	.000665	.001332	.000001
33,000	.008988	.000333	.007989	.000666	.000999	— .000333
34,000	.009987	.000999	.008655	.000666	.001332	.000333
35,000	.010985	.000998	.009654	.000999	.001331	— .000001
36,000	.011984	.000999	.010652	.000998	.001332	.000001
37,000	.012982	.000998	.011651	.000999	.001331	— .000001
38,000	.014314	.001332	.012650	.000999	.001664	.000333
39,000	.016644	.002330	.014980	.002330	.001664	— .000000
40,000	.017643	.000999	.016311	.001331	.001332	— .000332
41,000	.018975	.001332	.017310	.000999	.001665	.000333
42,000	.020639	.001664	.018642	.001332	.001997	.000332
43,000	.021971	.001332	.020306	.001664	.001665	— .000332
44,000	.023635	.001664	.021305	.000999	.002330	.000665
45,000	.024967	.001332	.022036	.001331	.002331	.000001
46,000	.028296	.003329	.026298	.003662	.001998	— .000333
47,000	.029974	.001678	.027966	.001668	.001998	— .000000
48,000	.031957	.001983	.029627	.001661	.002330	.000332
49,000	.034288	.002331	.031957	.002330	.002331	.000001
50,000	.036285	.001997	.033288	.001331	.002997	+ .000666
51,000	.038282	.001997	.035952	.002664	.002330	— .000667
52,000	.040612	.002330	.037616	.001664	.002996	.000666
53,000	.045939	.005327	.043608	.005992	.002331	— .000665

Table showing the extension, restoration, and permanent set, &c.—Continued.

SPECIMEN MARKED 9—Continued.

Weight per square inch of original area.	Extension per inch in length.	Successive extension per inch in length.	Restoration per inch in length.	Successive restoration per inch in length.	Permanent set per inch in length.	Successive permanent set per inch in length.
Pounds.	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
54, 000	.048601	.002662	.045939	.002331	.002662	.000331
55, 000	.052260	.003659	.049933	.003994	.002327	—.000335
56, 000	.055592	.003332	.052263	.002330	.003329	.001002
57, 000	.064580	.008988	.061584	.009321	.002996	—.000333
58, 000	.067909	.003329	.065246	.003662	.002663	.000333
59, 000	.072903	.004994	.068242	.002996	.004661	.001998
60, 000	.074900	.001997	.071571	.003329	.003329	—.001332
61, 000	.086884	.011984	.083888	.012317	.002996	—.000333
62, 000	.096537	.009653	.093542	.009654	.002995	—.000001
63, 000	.104860	.008323	.101198	.007656	.003662	.000667
64, 000	.122836	.017976	.118841	.017643	.003995	.000333
65, 000	.147803	.024967	.144141	.025300	.003662	—.000333
66, 000	.261318	.113515	(*)	(*)	(*)	(*)

* Specimen broke.

GENERAL SUMMARY.

Specific gravity	7. 8531
Hardness	10. 15
Original area of cross-section ... square inch	0. 248
Elastic limit ... pounds	20, 000
Extension per inch at elastic limit ... inch	0. 000999
Ultimate resistance per square inch of original area ... pounds	66, 000
Ultimate extension per inch ... inch	0. 261318
Ratio of elastic to ultimate resistance	3. 30
Contraction in area at fracture ... per cent	48. 18
Ultimate resistance per square inch of fractured area ... pounds	116, 283
Position of fracture	near center.
Character of surface	fibrous.

Table showing the extension, restoration, and permanent set caused by the undermentioned weights per square inch of area acting upon a solid cylinder of Firth's steel 3 *inches long and* .559 *inch in diameter, taken from breech-receiver of* 11-*inch chambered breech-loading rifle No.* 1 (*after rupture*).

SPECIMEN MARKED 10.

Weight per square inch of original area.	Extension per inch in length.	Successive extension per inch in length.	Restoration per inch in length.	Successive restoration per inch in length.	Permanent set per inch in length.	Successive permanent set per inch in length.
Pounds.	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
1, 000	.000000	.000000	.000000	.000000	.000000	.000000
2, 000	.000000	.000000	.000000	.000000	.000000	.000000
3, 000	.000000	.000000	.000000	.000000	.000000	.000000
4, 000	.000000	.000000	.000000	.000000	.000000	.000000
5, 000	.000000	.000000	.000000	.000000	.000000	.000000
6, 000	.000000	.000000	.000000	.000000	.000000	.000000
7, 000	.000000	.000000	.000000	.000000	.000000	.000000
8, 000	.000000	.000000	.000000	.000000	.000000	.000000
9, 000	.000000	.000000	.000000	.000000	.000000	.000000
10, 000	.000000	.000000	.000000	.000000	.000000	.000000
11, 000	.000000	.000000	.000000	.000000	.000000	.000000
12, 000	.000333	.000333	.000333	.000333	.000000	.000000
13, 000	.000667	.000334	.000667	.000334	.000000	.000000
14, 000	.000667	.000000	.000667	.000000	.000000	.000000
15, 000	.000667	.000000	.000667	.000000	.000000	.000000
16, 000	.000667	.000000	.000667	.000000	.000000	.000000
17, 000	.000667	.000000	.000667	.000000	.000000	.000000
18, 000	.000667	.000000	.000667	.000000	.000000	.000000
19, 000	.000667	.000000	.000667	.000000	.000000	.000000
20, 000	.000667	.000000	.000667	.000000	.000000	.000000
21, 000	.009667	.000000	.000667	.000000	.000000	.000000
22, 000	.000667	.000000	.000667	.000000	.000000	.000000
23, 000	.000667	.000000	.000667	.000000	.000000	.000000

Table showing the extension, restoration, and permanent set, &c.—**Continued.**

SPECIMEN MARKED 10—Continued.

Weight per square inch of original area.	Extension per inch in length.	Successive extension per inch in length.	Restoration per inch in length.	Successive restoration per inch in length.	Permanent set per inch in length.	Successive permanent set per inch in length.
Pounds.	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
24, 000	.000667	.000000	.000667	.000000	.000000	.000000
25, 000	.001333	.000666	.000667	.000000	.000666	.000666
26, 000	.002333	.001000	.001333	.000666	.001000	.000334
27, 000	.003667	.001334	.002667	.001334	.001000	.000000
28, 000	.004667	.001000	.003667	.001000	.001000	.000000
29, 000	.005333	.000666	.004333	.000666	.001000	.000000
30, 000	.006000	.000667	.005000	.000667	.001000	.000000
31, 000	.006667	.000667	.005667	.000667	.001000	.000000
32, 090	.009000	.002333	.007333	.001666	.001667	.000667
33, 000	.010000	.001000	.008333	.001000	.001667	.000000
34, 000	.010667	.000667	.009000	.000667	.001667	.000000
35, 000	.011667	.001000	.010000	.001000	.001667	.000000
36, 000	.012000	.000333	.011667	.001667	.000333	—.001334
37, 000	.013000	.001000	.012000	.000333	.001000	.000667
38, 000	.014000	.001000	.012333	.000333	.001667	.000667
39, 000	.015000	.001000	.013333	.001000	.001667	.000000
40, 000	.016333	.001333	.015000	.001667	.001333	—.000334
41, 000	.019333	.003000	.017333	.002333	.002000	.000667
42, 000	.020333	.001000	.018667	.001334	.001666	—.000334
43, 000	.021333	.001000	.019333	.000666	.002000	.000334
44, 000	.022333	.001000	.020333	.001000	.002000	.000000
45, 000	.024000	.001667	.022333	.002000	.001667	—.000333
46, 060	.027000	.003000	.024667	.002334	.002333	.000666
47, 000	.028667	.001667	.026667	.002000	.002000	—.000333
48, 000	.030667	.002000	.028333	.001666	.002334	.000334
49, 000	.032667	.003000	.030000	.001667	.002667	.000333
50, 000						
51, 000	.036333	.003666	.033667	.003667	.002666	—.000001
52, 000	.038667	.002334	.036000	.002333	.002667	.000001
53, 000	.041667	.003000	.039000	.003000	.002667	.000000
54, 000	.045333	.003666	.042667	.003667	.002666	—.000001
55, 000	.048333	.003000	.045667	.003000	.002666	.000000
56, 000	.052000	.003667	.049333	.003666	.002667	.000001
57, 000	.056000	.004000	.052667	.003334	.013333	.000666
58, 000	.059338	.003333	.055667	.003000	.003666	.000333
59, 000	.062667	.003334	.059667	.004000	.003000	—.000666
60, 000	.067333	.004666	.063667	.004000	.003666	.000666
61, 000	.074833	.007000	.071000	.007333	.003333	—.000333
62, 000	.079667	.005334	.076000	.005000	.003667	.000334
63, 000	.091000	.011333	.087333	.001133	.003667	.000000
64, 000	.098667	.007667	.095300	.007667	.003667	.000000
65, 000	.116000	.017333	.112000	.017000	.004000	.000333
66, 000	.136667	.020667	.132667	.020667	.004000	.000000
67, 000	.243667	.107000	(*)	(*)	(*)	(*)

*Specimen broke.

GENERAL SUMMARY.

Specific gravity	7.8[illegible]
Hardness	11.56
Original area of cross-section ... square inches..	0.2454
Elastic limit ... pounds..	24,000
Extension per inch at elastic limit ... inch..	0.000667
Ultimate resistance per square inch of original area ... pounds..	67,000
Ultimate extension per inch ... inch..	0.243667
Ratio of elastic to ultimate resistance	2.79
Contraction in area of fracture ... per cent..	42.99
Ultimate resistance per square inch of fractured area ... pounds..	117.519
Position of fracture	near center.
Character of surface	fibrous.

Table showing the extension, restoration, and permanent set caused by the undermentioned weights per square inch of area acting upon a solid cylinder of Firth's steel, 2.993 *inches long and* .564 *inches in diameter, taken from breech receiver of* 11-*inch chambered breech-loading rifle No.* 1 (*after rupture*).

SPECIMEN MARKED 11.

Weight per square inch of original area.	Extension per inch in length.	Successive extension per inch in length.	Restoration per inch in length.	Successive restoration per inch in length.	Permanent set per inch in length.	Successive permanent set per inch in length.
Pounds.	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
1, 000	.000000	.000000	.000000	.000000	.000000	.000000
2, 000	.000000	.000000	.000000	.000000	.000000	.000000
3, 000	.000000	.000000	.000000	.000000	.000000	.000000
4, 000	.000334	.000334	.000334	.000334	.000000	.000000
5, 000	.000334	.000000	.000334	.000000	.000000	.000000
6, 000	.000334	.000000	.000334	.000000	.000000	.000000
7, 000	.000334	.000000	.000334	.000000	.000000	.000000
8, 000	.000668	.000334	.000668	.000334	.000000	.000000
9, 000	.000668	.000000	.000668	.000000	.090000	.000000
10, 000	.000668	.000000	.000668	.000000	.000000	.000000
11, 000	.000668	.000000	.000668	.000000	.000000	.000000
12, 000	.000668	.000000	.000668	.000000	.000000	.000000
13, 000	.000668	.000000	.000668	.000000	.000000	.000000
14, 000	.001002	.000334	.000334	—.000334	.000668	.000668
15, 000	.001002	.000000	.000334	.000000	.000668	.000000
16, 000	.001002	.000000	.000334	.000000	.000668	.000000
17, 000	.001002	.000000	.000334	.000000	.000668	.000000
18, 000	.001336	.000334	.000668	.000334	.000668	.000000
19, 000	.002005	.000669	.001336	.000668	.000669	.000001
20, 000	.002673	.000668	.002005	.000669	.000668	—.000001
21, 000	.003007	.000334	.002339	.000334	.000668	.000000
22, 000	.003341	.000334	.002673	.090334	.000668	.000000
23, 000	.003341	.000000	.002673	.000000	.000668	.000000
24, 000	.003341	.000000	.002673	.000000	.000668	.000000
25, 000	.004009	.000668	.003007	.000334	.001002	.000334
26, 000	.004343	.000334	.004009	.001002	.000334	—.000668
27, 000	.005346	.001003	.004343	.000334	.001003	.000669
28, 000	.006682	.001336	.005346	.001003	.001336	.000333
29, 000	.007347	.000665	.006014	.060668	.001333	—.000003
30, 000	.009021	.001674	.007685	.001671	.001336	.000003
31, 000	.010023	.001002	.008353	.000668	.001672	.000334
32, 000	.011026	.001003	.009355	.001002	.001667	.000001
33, 000	.011691	.000665	.010692	.001337	.000999	—.000672
34, 000	.012696	.001005	.012028	.001336	.000668	—.000331
35, 000	.014367	.001671	.012362	.000334	.002005	.001337
36, 000	.015035	.000668	.013699	.001337	.001336	—.000669
37, 000	.016037	.001002	.014367	.000668	.001670	.000334
38, 000	.016706	.000669	.015369	.001002	.001337	.000333
39, 000	.017708	.001002	.016037	.000668	.001671	.000334
40, 000	.019044	.001336	.017374	.001337	.001670	—.000001
41, 000	.020047	.001003	.018711	.001337	.001336	.000334
42, 000	.022385	.002338	.020715	.002004	.001670	.000334
43, 000	.024390	.002005	.021717	.001002	.002673	.001003
44, 000	.025727	.001337	.024056	.002339	.001671	—.001002
45, 000	.027063	.002336	.025727	.001671	.001336	—.000335
46, 000	.031072	.004009	.028734	.003007	.002338	.001002
47, 000	.032075	.001003	.029402	.000668	.002673	.000335
48, 000	.034748	.002673	.032075	.002673	.002673	.000000
49, 000	.036084	.001336	.034413	.002338	.001671	—.000002
50, 000	.038089	.002005	.036084	.001671	.002005	.000334
51, 000	.040093	.002004	.037421	.001337	.002672	.000667
52, 000	.043768	.003675	.041096	.003675	.002672	.000000
53, 000	.045770	.002002	.043100	.002004	.002670	—.000002
54, 000	.049449	.003679	.046442	.003342	.003007	.000337
55, 000	.053458	.004009	.050785	.004343	.002673	—.000334
56, 000	.057467	.004009	.054457	.003672	.003010	.000337
57, 000	.061477	.004010	.058136	.003679	.003341	.000331
58, 000	.063812	.002335	.060808	.002672	.003004	—.000337
59, 000	.073171	.010359	.069830	.009022	.003341	.000337
60, 000	.076846	.003675	.071173	.004343	.002673	—.000668
61, 000	.082192	.005346	.078851	.004678	.003341	.000668
62, 000	.091881	.009689	.088206	.009355	.003675	+.000334
63, 000	.102907	.011026	.099231	.011025	.003676	.000001
64, 000	.109255	.006348	.105579	.006348	.003676	.000000
65, 000	.125961	.016706	.122285	.016706	.003676	.000000
66, 000	.151352	.025391	.147340	.025055	.004012	.000336
67, 000	.233211	.081889	....	....	....	....

GENERAL SUMMARY.

Specific gravity	7. [illegible]
Hardness	10.37
Original area of cross-section .... sq. inch..	0. [illegible]
Elastic limit .... pounds..	13,[illegible]
Extension per inch at elastic limit .... inch..	0. [illegible]
Ultimate resistance per square inch of original area .... pounds..	67,[illegible]
Ultimate extension per inch .... inch..	0. [illegible]
Ratio of elastic to ultimate resistance	5.15
Contraction in area at fracture	39.43 per cent.
Ultimate resistance per square inch of fractured area .... pounds..	110,61[illegible]
Position of fracture	near center.
Character of surface	fibrous and crystalline

Table showing the extension, restoration, and permanent set caused by the undermentioned weights per square inch of area acting upon a solid cylinder of Firth's steel, 3 *inches long and* .561 *inches in diameter, taken from breech receiver of* 11-*inch chambered breech-loading rifle No.* 1 (*after rupture*).

SPECIMEN MARKED 12.

Weight per square inch of original area.	Extension per inch in length.	Successive extension per inch in length.	Restoration per inch in length.	Successive restoration per inch in length.	Permanent set per inch in length.	Successive permanent set per inch in length.
Pounds.	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
1,000	.000000	.000000	.000000	.000000	.000000	.000000
2,000	.000000	.000000	.000000	.000000	.000000	.000000
3,000	.000333	.000333	.000333	.000333	.000000	.000000
4,000	.000333	.000000	.000333	.000000	.000000	.000000
5,000	.000333	.000000	.000333	.000000	.000000	.000000
6,000	.000333	.000000	.000333	.000000	.000000	.000000
7,000	.000333	.000000	.000333	.000000	.000000	.000000
8,000	.000333	.000000	.000333	.000000	.000000	.000000
9,000	.000667	.000334	.000667	.000334	.000000	.000000
10,000	.000667	.000000	.000667	.000000	.000000	.000000
11,000	.000667	.000000	.000667	.000000	.000000	.000000
12,000	.000667	.000000	.000667	.000000	.000000	.000000
13,000	.000667	.000000	.000667	.000000	.000000	.000000
14,000	.001000	.000333	.001000	.000333	.000000	.000000
15,000	.001000	.000000	.001000	.000000	.000000	.000000
16,000	.001000	.000000	.001000	.000000	.000000	.000000
17,000	.001000	.000000	.001000	.000000	.000000	.000000
18,000	.001333	.000333	.000333	—.000667	.001000	.001000
19,000	.001333	.000000	.000333	.000000	.001000	.000000
20,000	.001667	.000334	.000667	.000334	.001000	.000000
21,000	.002000	.000333	.001333	.000666	.000667	—.000333
22,000	.003000	.001000	.002000	.000667	.001000	.000333
23,000	.004000	.001000	.002667	.000667	.001333	.000333
24,000	.004667	.000667	.003667	.001000	.001000	—.000333
25,000	.005667	.001000	.004667	.001000	.001000	.000000
26,000	.006667	.001000	.005333	.000666	.001334	.000334
27,000	.007333	.000666	.006000	.000667	.001333	—.000001
28,000	.008000	.000667	.006667	.000667	.001333	.000000
29,000	.008333	.000333	.007000	.000333	.001333	.000000
30,000	.009000	.000667	.007333	.000333	.001667	.000334
31,000	.010333	.001333	.009000	.001667	.001333	—.000334
32,000	.011333	.001000	.010000	.001000	.001333	.000000
33,000	.012333	.001000	.011000	.001000	.001333	.000000
34,000	.013000	.000667	.011667	.000667	.001333	.000000
35,000	.014000	.001000	.012667	.001000	.001333	.000000
36,000	.015667	.001667	.014000	.001333	.001667	.000334
37,000	.016667	.001000	.015333	.001333	.001334	—.000333
38,000	.018000	.001333	.016000	.000667	.002000	.000666
39,000	.019333	.001333	.017333	.001333	.002000	.000000
40,000	.020667	.001334	.019000	.001667	.001667	—.000333
41,000	.022333	.001666	.020667	.001667	.001666	—.000001
42,000	.024000	.001667	.022333	.001666	.001667	.000001
43,000	.025333	.001333	.023333	.001000	.002000	.000333
44,000	.027000	.001667	.025000	.001667	.002000	.000000
45,000	.030333	.003333	.028333	.003333	.002000	.000000
46,000	.032333	.002000	.030333	.002000	.002000	.000000
47,000	.035333	.003000	.032667	.002334	.002666	.000666
48,000	.037000	.001667	.034667	.002000	.002333	—.000333
49,000	.038667	.001667	.036333	.001666	.002334	.000001
50,000	.040333	.001666	.037667	.001334	.002666	.000332
51,000	.042333	.002000	.040000	.002334	.002333	—.000333
52,000	.048000	.005667	.045333	.005333	.002667	.000334

Table showing the extension, restoration, and permanent set, &c.—Continued.

Weight per square inch of original area.	Extension per inch in length.	Successive extension per inch in length.	Restoration per inch in length.	Successive restoration per inch in length.	Permanent set per inch in length.	Successive permanent set per inch in length.
Pounds.	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
53, 000	. 049667	. 001667	. 047333	. 002000	. 002334	— . 000333
54, 000	. 053667	. 004000	. 051000	. 003667	. 002667	. 000333
55, 000	. 057667	. 004000	. 055500	. 004000	. 002667	. 000000
56, 000	. 062000	. 004333	. 059000	. 004000	. 003000	+ . 000333
57, 000	. 066333	. 004333	. 063667	. 004667	. 002666	— . 000334
58, 000	....	....	....	....	....	....
59, 000	. 070667	. 004334	. 067333	. 003666	. 003334	. 000668
60, 000	. 075667	. 005000	. 072333	. 005000	. 003334	. 000000
61, 000	. 081333	. 005666	. 078667	. 006334	. 002666	— . 000668
62, 000	. 094667	. 013334	. 092000	. 013333	. 002667	. 000001
63, 000	. 104000	. 009333	. 100667	. 008667	. 003333	. 000666
64, 000	. 118667	. 014667	. 115000	. 004333	. 003667	. 000334
65, 000	. 134000	. 015333	. 130333	. 015333	. 003667	. 000000
66, 000	. 158333	. 024333	. 154667	. 024334	. 003666	— . 000001
67, 000	. 244000	. 085667	(*)	(*)	(*)	(*)

* Specimen broke.

GENERAL SUMMARY.

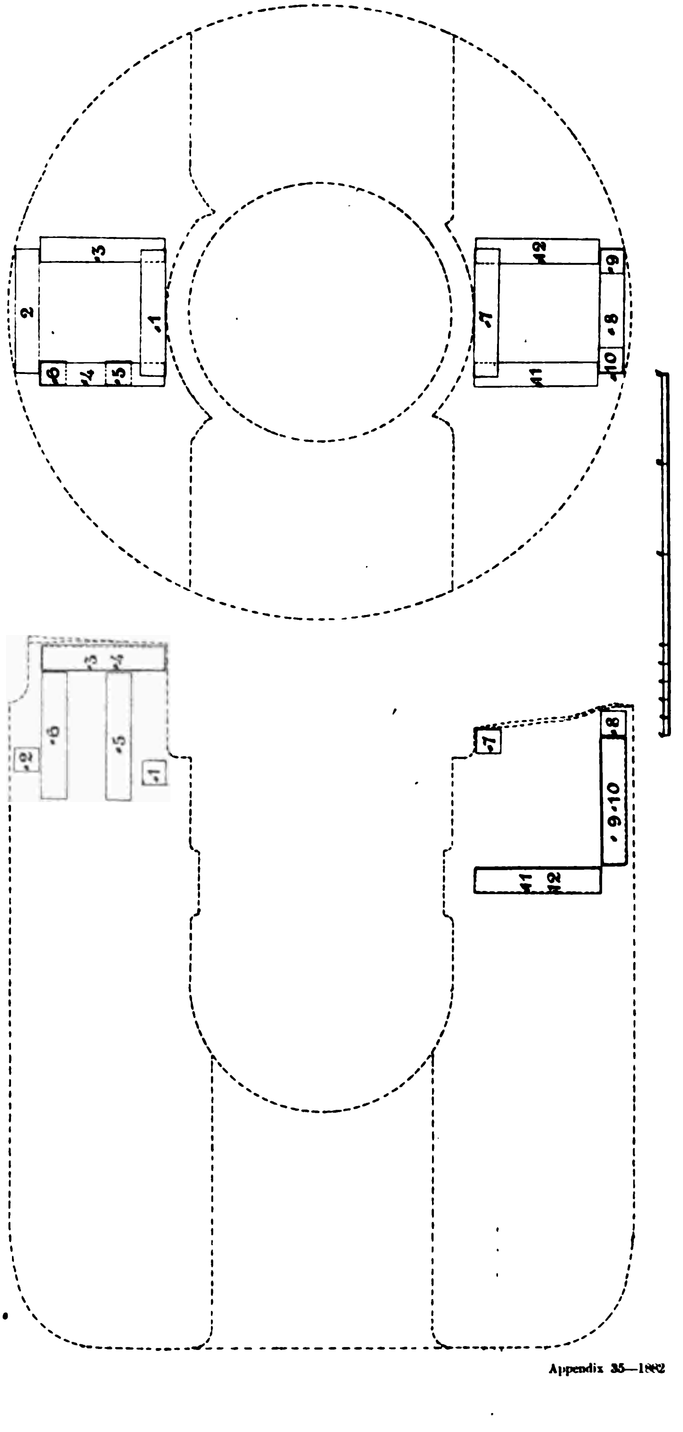
Specific gravity		7. 8527
Hardness		10. 82
Original area of cross-section	square inches..	0. 2471
Elastic limit	pounds..	17, 000
Extension per inch at elastic limit	inches..	0. 001000
Ultimate resistance per square inch of original area	pounds..	67, 000
Ultimate extension per inch	inches..	0. 244000
Ratio of elastic to ultimate resistance		3. 94
Contraction in area at fracture	per cent..	39. 01
Ultimate resistance per square inch of fractured area	pounds..	109, 852
Position of fracture		near center.
Character of surface		fibrous

Summary of mechanical tests of Firth's steel taken from breech receiver of 11-*inch B. L. rifle No.* 1, *chambered* (*after rupture*).

No. of specimen.	Kind.	Location.	Specific gravity.	Hardness.	Elastic limit.	Extension per inch at elastic limit.	Ultimate resistance per square inch of original area.	Ultimate extension per inch.	Ratio of elastic to ultimate resistance.	Original area of cross-section.	Contraction in area at fracture.	Ultimate resistance per square inch of fractured area.	Position of fracture.	Character of surface.
					Pounds.	*Inch.*	*Pounds.*	*Inch.*		*Sq. inch.*	*Per cent.*	*Pounds.*		
1	Tangential	Interior	7.8871	10.82	19,000	0.000667	64,000	0.123333	3.37	0.2489	43.67	113,617	Near center.	Fibrous.
7	do	do	7.8581	10.82	10,000	0.000667	65,000	0.258667	6.50	0.248	27.82	90,055	do	Do.
2	do	Exterior	7.8519	10.37	15,000	0.000671	67,000	0.221426	4.47	0.2454	38.87	109,545	do	Do.
8	do	do	7.8762	10.37	12,000	0.000667	65,000	0.170059	5.41	0.2489	43.79	115,643	do	Do.
	Mean		7.8683	10.59½	14,000	0.000668	65,250	0.194871	4.94	0.2478	38.54	107,215		
3	Radial	Surface	7.8600	10.37	13,000	0.000667	66,000	0.239000	4.62	0.2463	41.86	113,512	Near center	Fibrous.
4	do	do	7.8617	10.37	16,000	0.001344	65,000	0.238239	4.06	0.2498	36.35	103,386	do	Do.
11	do	Interior	7.8690	10.37	13,000	0.000668	67,000	0.233211	5.15	0.2498	39.43	110,612	do	Do.
12	do	do	7.8527	10.82	17,000	0.001000	67,000	0.244000	3.94	0.2471	39.01	109,852	do	Do.
	Mean		7.86085	10.48	14,750	0.000919	66,250	0.238612	4.44	0.24825	39.16	109,340		
9	Longitudinal	Exterior	7.8531	10.15	20,000	0.000999	66,000	0.261318	3.30	0.248	43.18	116,283	Near center.	Fibrous.
10	do	do	7.8808	11.59	24,000	0.000667	67,000	0.243667	2.79	0.2454	42.99	117,519	do	Do.
5	do	Interior	7.8588	10.60	18,000	0.001001	66,000	0.266789	3.66	0.248	37.58	105,736	do	Do.
*6	do	do	7.8662	10.82	12,000	0.001002	64,000	0.086869	5.33	0.2489	7.59	69,562	do	Do.
	Mean (*No. 6 omitted)		7.8642	10.78	20,666	0.000889	66,333	0.257258	3.25	0.2471	41.25	113,179		
	Mean (*No. 6 omitted)		7.8645	10.60	16,091	0.000820	65,909	0.227792	4.297	0.2478	39.50	109,614		

PLATE I.

Showing location of specimens taken from 11 b.l. rifle



APPENDIX 36.

REPORT ON THE 8-INCH BREECH-LOADING CHAMBERED RIFLE No.

(5 plates.)

Five 8-inch B. L. rifles were made by the department, under the contracts for the year ending June, 1881, and these were proved by the assistant to constructor of ordnance at Sandy Hook, N. J. One of these guns broke at the third round, the breech-receiver breaking through the front end of slot for breech-block, and this rear part with the block was thrown violently to the rear a considerable distance. Attention of the department was then called to the fact that the front corners of the breech-slot were square and not rounded, as is usually done where two surfaces of steel or iron are at right angles to each other. It was then thought that this sharp angle furnished an initial point to start rupture, and was the principal cause of this rupture. By your direction, therefore, this gun had these corners rounded (Plate I) and the Board was directed by you to fire it 100 rounds. The trial commenced November 11, 1881, with 50 pounds of powder (10 A, No. 7, density 1.785, granulation 67), and 179-pound projectile, Hotchkiss, and was continued from time to time (delays being occasioned by projectiles not being delivered on time) until December 16, 1881, when the 100 rounds were completed. As the average velocities and pressures had only been 1,527 feet, and 32,606 pounds, respectively, at the suggestion of the Board, approved by you, the gun was authorized to be fired 25 additional rounds, changing the character of the powder, so as to obtain increased pressures and velocities. This firing was commenced December 28, 1881, and 15 rounds were fired giving an average pressure of 43,600 pounds, and 1662.6 feet velocity.

The powder was here again changed, it being determined to run up the pressures somewhat higher for the last 10 rounds, and this was accordingly commenced, but at the 7th round with this powder the gun burst violently, the rupture being tangential. The average (leaving out the last) pressures and velocities with this powder were 51,000 pounds and 1,710 feet, respectively. These pressures are not regarded as excessive, and as the weight of charge of powder for which the gun was chambered was not exceeded, it was an occasion very likely to arise in service, in using powders of same density and granulation. The last pressure was not counted in making up the average, as it was probably exaggerated by the pressure plug being thrown violently against a shield placed in rear of the gun, and the velocity for this round was lower than the former ones, while the pressures for the latter were lower and quite uniform.

A sketch of the fragments as they lay after the explosion is herewith appended (Plate II).

A sketch of the fragments showing powder stains is also inclosed (Plate III).

Sketches of the fragments as they were collected and assembled together after explosion are also inclosed (Plates IV and V).

The record of firing is also forwarded with these papers.

The Board is not able to state with certainty, from the results with this one gun, that the rounding of the corners of the breech-slot saved it from longitudinal rupture, but the experiment seems to point in that direction. The tangential rupture, although unexpected, did not occur until after the gun had endured a severe test, and it showed that the gun was about equally strong in all its parts, and that this chambering of 55 pounds is too great for a gun of this caliber.

In this connection the Board would like to offer the following statement:

The procurement of muzzle-loading converted guns by lining cast-iron with wrought-iron tubes by the department was certainly justified by the successful tests to which they were subjected at the Sandy Hook proving ground; but the necessity of obtaining B. L. rifles was so evident that the department authorized the trial of an 8-inch B. L. rifle with the Krupp fermeture (supposed at that time to be the best known). and its successful trial up to 500 rounds warranted the procurement of others of the same caliber for service, and of some larger calibers for trial at least, but the result of recent experiments shows very clearly the difficulty of procuring steel in such large masses of the requisite qualities for constructions of this character.

When a material possesses such a superiority in respect of strength, ductility, and light elastic limit, as does good steel compared with any other form of iron, and when for commercial purposes, such as bridge trusses, ship plates, boiler plates, and rails, structures liable to be exposed to great strains, to violent shocks, or both, it is surely replacing wrought iron as the latter replaced cast iron whenever possible, it seems that the future use of steel in gun construction is a foregone conclusion.

Although difficulty has been encountered in procuring a uniform product where the substance has to be used in large masses, it cannot be asserted that there is any inherent difficulty that cannot be overcome.

Uniformity of yield depends upon many factors, some of which are unknown quantities, and, in the present state of science, may be unknowable; but a knowledge of the circumstances which influence the product is rapidly increasing. It is probable that the quality of steel required for gun construction has not been thoroughly and systematically investigated in this country, and that such an investigation carefully and judiciously pursued would be of great value to the government directly, and indirectly to all concerned in steel manufacture.

The system to be pursued is indicated by the successful efforts of the Ordnance Department to increase the strength and homogeneity of cast iron. Uniform treatment in preparing ores, in their reduction, in the graduated mixture of the resulting pig iron, infusion in the air furnace, supplemented by a careful examination and comparison of the qualities of the completed product, its application to gun construction, and a comparison of the metal in such guns as gave high endurance, with new guns made under precisely the same circumstances, threw a flood of light upon a system which has been largely empirical.

To diminish the first cost of experimentation, and to undertake what can probably be achieved in this country with the experience and mechanical appliances now in existence, the construction of a field gun of 3.5 inches caliber could be attempted. If successful, an order for eight might be given as a stimulus to the successful producers of a single one.

Before giving an order, or asking for the money necessary to do so, a careful study of the resources of the steel establishments should be undertaken.

For the Bessemer steel producers of America, this information has recently been collated and published by Mr. H. L. Holly, of Brooklyn.

For the other steels, generally known as open-hearth steels, obtained by the Siemens direct or the Siemens-Martin processes, the information could be obtained by inquiry and correspondence.

For the crucible steel the same method may be resorted to. In any case such information would be at least useful to the Ordnance Department.

It is suggested that, in connection with this, a series of experiments be directed with the machine at Watertown Arsenal for determining the quality of such American steel as may be used in gun construction, for in departing from an old system of construction it would seem judicious to take advantage of a new, more accurate, and more powerful device for testing.

Record of firing with 8-inch breech-loading rifle No. 2, chambered,

[Gun mounted on carriage

	Number of fire.	Time.	Powder.		Projectile.		Elevation in degrees.
			Kind.	Weight, pounds.	Kind.	Weight, pounds.	
		1881.					
Proof-rounds fixed by constructor of ordnance.	1						
	2						
	3						
	4						
	5						
Barometer, 30.46; thermometer, 47; relative humidity, 42 per cent.; wind, 1 mile an hour.	6	Nov. 11	Du Pont's hexagonal I. O. A. No. 7. Density, 1.785; granulation, 67.	50	Hotchkiss (ressaboted).	179	−
	7	Nov. 11	......do	50	....do	179	−
	8	Nov. 11	......do	50	.. do	179	−
	9	Nov. 11	......do	50	Hotchkiss (new)	180	−
	10	Nov. 11	......do	50	Hotchkiss (ressaboted).	179	−
	11	Nov. 11	......do	50	......do	180	−
	12	Nov. 11	......do	50	Hotchkiss (new)	180	−
Barometer, 30.53; thermometer, 56; relative humidity, 74 per cent.; wind, 16 miles an hour.	13	Nov. 12	......do	50	Hotchkiss (ressaboted).	178	−
	14	Nov. 12	......do	50	... do	178	−
	15	Nov. 12	...... do	50	....do	178	−
	16	Nov. 12	......do	50	....do	179	−
	17	Nov. 12	......do	50	....do	179	−
	18	Nov. 12	......do	50	....do	178	−
	19	Nov. 12	......do	50	....do	178	−
Barometer, 30.633; thermometer, 46; relative humidity, 53 per cent.; wind, 10 miles an hour.	20	Nov. 16	......do	50	....do	178	−
	21	Nov. 16	......do	50	Butler* (new)	180	−
	22	Nov. 16	......do	50	....do	180	−
	23	Nov. 16	...... do	50	....do	180	−
	24	Nov. 16	......do	50	....do	180	−
Barometer, 30.561; thermometer, 54; relative humidity, 74 per cent.; wind, 14 miles an hour.	25	Nov. 17	......do	50	....do	181	−
	26	Nov. 17	......do	50	....do	181	−
	27	Nov. 17	......do	50	....do	181	−
	28	Nov. 17	......do	50	... do	181	−
	29	Nov. 17	......do	50	....do	181	−
	30	Nov. 17	......do	50	....do	182	−

at Sandy Hook, N. J., from November 11, 1881, *to December* 30, 1881.

with hydraulic buffer.]

Pressure, pounds per square inch of bore.	Instrumental velocity, taken 108 feet from muzzle.	Kind of knife.	Kind of sabot.	Direction of wind as regards line of fire.		Special remarks about each fire, such as effect on piece, sound of projectile in flight, scattering of fragments, &c.	
....	....	......	....	....		After 5th round the front horizontal angles (right angles) of the breech slot were rounded with a radius of 0″.32, in compliance with instructions from Chief of Ordnance as contained in indorsement of November 3, 1881.	
....	....	......	....	....			
....	....	......	....	....			
....	....	......	....	....			
....	....	......	....	....			
33, 000	1, 567	......	Copper..	From rear and right.	Fired into sand butt. No escape of gas.	Breech block closed easily; opened hard.	
34, 000	1, 556	......	...do			Breech block closed and opened hard—two men.	
33, 500	1, 541	......	...do			Do.	
34, 000	1, 533	......	.. do			Do.	
32, 500	1, 545	......	...do			Breech block c'osed and opened hard—two men and bar.	
32, 000	1, 556	......	.. do			Breech block closed hard—two men and bar; opened hard—two men.	
31, 500	1, 550	......	...do			Breech block closed very hard—two men and bar; opened hard—two men.	
31, 500	1, 558	......	...do	From front and left.		Breech block closed and opened hard—two men.	
32, 000	1, 547	......	...do ...			Breech block closed and opened hard—two men and bar.	
32, 000	1, 562	......	Brass ...			Do.	
31, 000	1, 566	......	...do			Do.	
32, 500	1, 571	......	...do			Do.	
31, 500	1, 570	......	.. do			Do.	
35, 000	1, 586	......	...do			Do.	
						Before 20th round new steel gas-check put in gun.	
31, 000	1, 565	O	...do	From front and left.	Fired into sand butt.	Closed easily—one man; opened hard—one man.	*Butler projectiles entered shot chamber 2¼″ more than Hotchkiss, giving this much more air-space.
29, 500	1, 444	D	....			Closed and opened easily—two men.	
30, 000	1, 443	O	....			Do.	Slight escape of gas between gas-check and gas-check seat. Round 23, sabot stripped in flight.
30, 500	1, 445	D	....			Do.	
24, 500	1, 446	O	....			Do.	
							Gas-check turned half way round.
27, 500	1, 431	D	....	From front and right.		Closed easily and opened hard—one man.	Rounds 26 to 30, sabots stripped in flight.
25, 500	1, 314	O	....			Closed hard—one man; opened easily—two men.	Escape of gas between gas check and gas-check seat. More escape at rounds 29 and 30 than at previous rounds.
30, 000	1, 452	D	....			Closed and opened easily—two men.	
26, 000	1, 428	O	....			Do.	
29, 000	1, 446	D	....			Do.	
25, 500	1, 422	O	....			Do.	

Before 20th round new obturator plate giving one inch more bearing surface for face of gas-check. After 28th round slight gas cuts were noticed between gas-check and seat, upper side, which were increased slightly at 29th and 30th round, when firing was discontinued, gas-check taken out, seat of gas-check turned out to remove gas cuts, and new steel gas-check made and fitted to it; variations between steel gas-checks (rounds 20 and 30) given below, making last check straighter and longer than previous one.

Diameter of gas-check (round 30) across face	10″.735
Diameter of gas-check (round 20) across face	10″.622
Diameter of gas-check (round 30) across lip..........	10″.440
Diameter of gas-check (round 20) across lip..... ..	10″.162
Diameter of gas-check (round 30) across face (inside).	8″.775
Diameter of gas-check (round 20) across face (inside).	8″.675
Length of gas-check (round 30).........................	1″.84
Length of gas-check (round 20).........................	1″.741

Record of firing with 8-inch breech-loading rifle No. 2,

[Gun mounted on carriag

	Number of fire.	Time.	Powder.		Projectile.		Elevation in degrees.
			Kind.	Weight, pounds.	Kind.	Weight, pounds.	
Barometer, 30.438; thermometer, 44; relative humidity, 67 per cent.; wind, 3 miles an hour.	31	1881. Nov. 29	Du Pont's hexagonal, I. O. A., No. 7. Density, 1.785; granulation, 67.	50	Hotchkiss (reasaboted).	177	−1
	32	Nov. 29	......do	50	... do	177	−1
	33	Nov. 29	......do	50	....do	177	−1
	34	Nov. 29	......do	50	....do	177	−1
	35	Nov. 29	......do	50	....do	177	−1
	36	Nov. 29	......do	50	....do	178	−1
	37	Nov. 29	......do	50	....do	178	−1
	38	Nov. 29	......do	50	....do	178	−1
	39	Nov. 29	......do	50	....do	178	−1
	40	Nov. 29	......do	50	....do	179	−1
Barometer, 30.375; thermometer, 43; relative humidity, 73 per cent.; wind, 4 miles an hour.	41	Nov. 30	......do	50	....do	178	−1
	42	Nov. 30	......do	50	....do	179	−1
	43	Nov. 30	......do	50	....do	179	−1
	44	Nov. 30	......do	50	....do	180	−1
	45	Nov. 30	......do	50	....do	180	−1
	46	Nov. 30	......do	50	.. do	180	−1
	47	Nov. 30	......do	50	....do	180	−1
	48	Nov. 30	......do	50	.. do	180	−1
	49	Nov. 30	......do	50	....do	180	−1
	50	Nov. 30	......do	50	....do	180	−1
A. M.—Barometer, 30.006; thermometer, 50; relative humidity, 84 per cent.; wind, 13 miles an hour.	51	Dec. 13	......do	50	....do	180	−1
	52	Dec. 13	......do	50	....do	180	−1
	53	Dec. 13	......do	50	....do	180	−1
	54	Dec. 13	......do	50	....do	180	−1
	55	Dec. 13	......do	50	....do	180	−1
	56	Dec. 13	......do	50	....do	180	−1
	57	Dec. 13	......do	50	....do	180	−1
	58	Dec. 13	......do	50	....do	180	−1
	59	Dec. 13	......do	50	....do	180	−1
	60	Dec. 13	......do	50	....do	180	−1
P. M.—Barometer, 30.128; thermometer, 61; relative humidity, 73 per cent.; wind, 24 miles an hour.	61	Dec. 13	......do	50	....do	180	−1
	62	Dec. 13	..... do	50	....do	180	−1
	63	Dec. 13	......do	50	....do	180	−1
	64	Dec. 13	......do	50	....do	180	−1
	65	Dec. 13	......do	50	....do	180	−1
	66	Dec. 13	......do	50	....dO	180	−1
	67	Dec. 13	......do	50	....do	180	−1
	68	Dec. 13	......do	50	....do	180	−1
	69	Dec. 13	......do	50	....do	180	−1
	70	Dec. 13	......do	50	Hotchkiss (new)..	180	−1

chambered, at Sandy Hook, N. J., &c.—Continued.

with hydraulic buffer.]

Pressure, pounds per square inch of bore.	Instrumental velocity, taken 108 feet from muzzle.	Kind of knife.	Kind of band.	Direction of wind as regards line of fire.		Special remarks about each fire, such as effect on piece, sound of projectile in flight, scattering of fragments, &c.
33,500	1,574	D	Copper	From rear and right.	Fired into sand butt.	
31,500	1,556	O	..do....			
34,000	1,555	D	..do.			After 33d round gas-check removed and examined; replaced and turned one-half around.
32,000	1,550	O	...do....			Closed and opened easily—one man. Slight escape of gas between gas-check and gas-check seat.
35,500	1,551	D	...do..			
32,000	1,553	O	...do..			
34,000	....	D	..do...			
Lost..	....	O	...do....			
35,500	....	D	...do...			
32,000	1,552	O	...do..			
35,000	....	D	.do....	From right.	Fired into sand butt.	
32,000	....	O	...do....			
33,500	....	D	...do....			
31,000	....	O	...do....			After 44th round gas-check removed, examined; not scarred, and replaced.
33,500	......	D	...do....			Closed and opened easily—one man; slight escape of gas between gas-check and gas-check seat.
31,000	....	O	...do....			After 46th round one quart oil put in cylinder.
35,500	....	D	...do....			
30,000	....	O	...do...			
35,500	....	D	..do...			
30,000	1,541	O	...do...			
						Knives marked O and D are similar in every respect, and were used in the same plug for purpose of comparison; the one marked D being a new knife and companion to one furnished Messrs. Du Pont & Co. New combination gas-check, copper and steel; shot copper lip. One quart of oil put in cylinder. 0″.015 turned off right side of obturator plate.
36,500	....	D	....	From right.	Fired into sand butt. No escape of gas.	Closed easily—one man; opened hard—two men.
38,500	....	O	....			Closed and opened hard—two men.
35,500	....	D	....			Closed and opened easily—two men.
32,500	....	O	....			Do.
36,500	....	D.	....			Do.
30,000	....	O	....			Do.
36,500	....	D	....			Do.
30,000	....	O	....			Do.
35,500	....	D	....			Do.
31,500	1,565	O	....			Do.
						After 60th round gun washed, examined, and star-gauged. One rear transom ball broken; replaced before firing. Before 61st round *steel gas-check* put in gun.
35,500	....	D	....	From right.	Fired into sand butt. Slight escape of gas between gas-check and seat.	Closed and opened easily—one man. Brace to loading platform broken and platform removed.
31,500	....	O	....			Closed and opened easily—one man. After 62d round gas-check removed and washed; also its seat; gas-check replaced. Obturator plate removed, cleaned, and replaced with a piece of sheet-brass, 0″.014 thick, in rear.
36,500	....	D	....			Closed and opened easily—one man.
32,000	....	O	....			Do.
35,500	....	D	....			Closed and opened easily—two men.
34,000	....	O	....			Do.
36,000	....	D	....			Do.
32,500	....	O	....			Do.
36,000	....	D	....			Do.
32,000	1,564	O	....			Closed and opened easily—two men; sabot stripped.
						After 70th round gun washed out, examined, and star-gauged. After 70th round loading platform repaired and replaced.

Record of firing with 8-inch breech-loading rifle No. 2

[Gun mounted on carria

			Powder.		Projectile.		
	Number of fire.	Time.	Kind.	Weight, pounds.	Kind.	Weight, pounds.	Elevation in degrees.
Barometer, 29.954; thermometer, 62; relative humidity, 80 per cent.; wind, 22 to 28 miles an hour.	71	1881. Dec. 14	Du Pont's hexagonal, I. O. A., No. 7. Density, 1.785; granulation, 67.	50	Hotchkiss (new)	180	–
	72	Dec. 14	do	50	do	181	–
	73	Dec. 14	do	50	do	181	–
	74	Dec. 14	do	50	do	181	–
	75	Dec. 14	do	50	do	181	–
	76	Dec. 14	do	50	do	183	–
	77	Dec. 14	do	50	do	183	–
	78	Dec. 14	do	50	do	183	–
	79	Dec. 14	do	50	Hotchkiss shot and sabot (old).	181	–
	80	Dec. 14	do	50	Hotchkiss (new)	182	–
Barometer, 30.657; thermometer, 30; relative humidity, 75 per cent.; wind, 17 miles an hour.	81	Dec. 16	do	50	Hotchkiss (resaboted).	182	–
	82	Dec. 16	do	50	do	180	–
	83	Dec. 16	do	50	do	178	–
	84	Dec. 16	do	50	do	178	–
	85	Dec. 16	do	50	do	181	–
	86	Dec. 16	do	50	do	180	–
	87	Dec. 16	do	50	do	178	–
	88	Dec. 16	do	50	do	178	–
	89	Dec. 16	do	50	do	181	–
	90	Dec. 16	do	50	do	181	–
Barometer, 30.657; thermometer, 30; relative humidity, 75 per cent.; wind, 17 miles an hour.	91	Dec. 16	do	50	Hotchkiss shot and sabot (old).	181	–
	92	Dec. 16	do	50	do	183	–
	93	Dec. 16	do	50	do	180	–
	94	Dec. 16	do	50	do	180	–
	95	Dec. 16	do	50	do	182	–
	96	Dec. 16	do	50	do	180	–
	97	Dec. 16	do	50	do	179	–
	98	Dec. 16	do	50	do	179	–
	99	Dec. 16	do	50	do	182	–
	100	Dec. 16	do	50	do	181	–
Barometer, 30.602; thermometer, 31; relative humidity, 78 per cent.; wind, 5 miles an hour.	101	Dec. 16	do	50	do	182	–
	102	Dec. 16	do	50	do	182	–
	103	Dec. 16	do	50	do	182	–
	104	Dec. 16	do	50	do	182	–
	105	Dec. 16	do	50	do	183	–

chambered, at Sandy Hook, N. J., &c.—Continued.

with hydraulic buffer.]

Pressure, pounds per square inch of bore.	Instrumental velocity, taken 108 feet from muzzle.	Kind of knife.	Kind of sabot.	Direction of wind as regards line of fire.		Special remarks about each fire, such as effect on piece, sound of projectile in flight, scattering of fragments, &c.
36, 000	....	D	....	From right and front.	Slight escape of gas.	Closed and opened easily—two men.
29, 000	....	O	....			Do.
37, 000	....	D	....			Closed and opened easily—two men. After 73d round gas-check taken out, washed, and replaced.
31, 500	....	O	....			Closed easily—one man; opened hard—two men. Both bolts holding rear end of trace to loading platform, broken; right side of carriage,
36, 000	....	D	....			Closed and opened easily—two men.
29, 500	....	O	....			Do.
37, 000	....	D	....			Do.
34, 000	....	O	....			Closed and opened hard—two men.
34, 500	1, 524	D	....			Do.
34, 000	1, 541	O	....			Do.
						After 80th round loading platform removed.
					Fired into sand butt.	After 80th round gun washed out, examined, and star-gauged.
						Before 81st round right side of obturator plate turned off 0''.007. Piece of brass, 0''.019 thick, put in rear of obturator plate, and angle formed by breech-block setting back against receiver, filed away.
34, 000	....	D	....	From left and rear.		Closed easily—one man; opened hard—one man.
30, 000	....	O	....			Do.
34, 000	....	D	....			Do.
32, 500	....	O	....			Do.
34, 000	....	D	....			Do.
31, 500	....	O	....			Do.
34, 500	....	D	....			Do.
32, 500	....	O	....			Do.
35, 500	....	D	....			Do.
33, 500	1, 549	O	....			Do.
32, 000	....	D	....	From left and rear.	Slight escape of gas.	
29, 500	....	O	....			
33, 500	....	D	....			
30, 500	....	O	....			
31, 000	....	D	....			
30, 000	....	O	....			
33, 500	....	D	....			
30, 000	....	O	....			
32, 000	....	D	....			
27, 000	....	O	....			Closed easily—one man. Opened hard—one man.
						After 100th round gun washed out, examined, and star-gauged.
37, 500	....	D	....	From rear and left.	Fired into sand butt.	From 88th to 100th round, inclusive, gas-check and obturator plate not wiped off; the slight escape of gas accumulating but making no apparent difference in effort to work breech-block.
33, 500	....	O	....			
37, 500	....	D	....			
33, 500	....	O	....			After 105th round gun washed out, star-gauged, and examined.
40, 000	1, 551	D	....			

Knives marked O and D are similar in every respect and were used in the same pressure plug—to include the 60th round—from round 61 to 105 inclusive. Knife marked D was used in separate plug, D being a new knife and companion to one furnished Messrs. Du Pont & Co.

Projectiles noted in this report as "Hotchkiss shot and sabot (old)" were shot recovered from the sand butt and fired the second time without rebanding; groove mark removed when shown necessary by the gauge. These shot entered shot chamber ½ inch further than new ones.

Before 106th round 2 quarts oil put in cylinder; combination gas-check, copper and steel. Before 106th round new vent-bushing put in gun.

Record of firing with 8-inch breech-loading rifle No. 2

[Gun mounted on carri

	Number of fire.	Time.	Powder. Kind.	Powder. Weight, pounds.	Projectile. Kind.	Projectile. Weight, pounds.	Elevation in degrees
Barometer, 29.967; thermometer, 47; relative humidity, 91 per cent.; wind, 4 miles an hour.	106	1881. Dec. 28	Du Pont's hexagonal I. O. A. No. 6. Density, 1.785; granulation, 67.	55	Hotchkiss (new)	180	–
	107	Dec. 28	......do	55	....do	181	–
	108	Dec. 28	......do	55	....do	181	–
	109	Dec. 28	......do	55	....do	181	–
	110	Dec. 28	......do	55	....do	181	–
	111	Dec. 28	......do	55	....do	182	–
	112	Dec. 28	......do	55	....do	182	–
	113	Dec. 28	......do	55	....do	182	–
Barometer, 29.932; thermometer, 47; relative humidity, 89 per cent.; wind, 2 miles an hour.	114	Dec. 28	......do	55	....do	182	–
	115	Dec. 28	......do	55	....do	182	–
	116	Dec. 28	......do	55	....do	182	–
	117	Dec. 28	......do	55	....do	182	–
	118	Dec. 28	......do	55	....do	183	–
	119	Dec. 28	......do	55	....do	183	–
	120	Dec. 28	......do	55	....do	183	–
Barometer, 29.506; thermometer, 42; relative humidity, 56 per cent.; wind, 26 miles an hour.	121	Dec. 30	Du Pont's hexagonal I. O. A. No. 1. Density, 1.785; granulation, 67.	55	Hotchkiss (reasaboted).	181	–
	122	Dec. 30	......do	55	....do	182	–
	123	Dec. 30	......do	55	....do	181	–
	124	Dec. 30	......do	55	....do	181	–
	125	Dec. 30	......do	55	....do	181	–
	126	Dec. 30	......do	55	....do	182	–
	127	Dec. 30	......do	55	....do	182	–

chambered, at Sandy Hook, N. J.—Continued.

with hydraulic buffer.]

Pressure, pounds per square inch of bore.	Instrumental velocity, taken 108 feet from muzzle.	Kind of knife.	Kind of sabot.	Direction of wind as regards line of fire.	Special remarks about each fire, such as effect on piece, sound of projectile in flight, scattering of fragments, &c.	
43,000	1,696	O	....	From left.	Fired into sand butt. Closed easily—one man; opened hard—two men. No escape of gas. Sabot stripped.	
32,000	1,650	D	....		Closed easily—two men; opened hard—two men.	Slight escape of gas lower left side. At 106th round front top bolt, right side loading platform, broken.
42,000	1,661	O	....		Closed and opened hard—two men and bar.	
43,000	1,669	D	....		Do.	
44,000	1,675	O	....		Do.	
44,500	1,658	D	....		Closed hard—two men; opened hard—two men and bar.	Sabot stripped. No escape of gas.
42,500	1,653	O	....		Do.	
44,500	1,660	D	....		Do.	
					After 113th round gun washed out, examined, and star-gauged.	
					At 114th round front transom bolt broken.	
44,500	1,686	O	....		Closed hard—two men; opened hard—two men and bar.	Sabot stripped. After 115th round loading platform removed. No escape of gas.
45,000	1,664	D	....		Do.	
39,500	1,646	O	....		Do.	
44,500	1,654	D	....		Do.	
44,500	1,662	O	....		Do.	
46,000	1,652	D	....		Do.	
44,500	1,653	O	....		Do.	Sabot stripped.
					After 120th round gun washed out, examined, and star-gauged.	
49,000	1,702	D	....	From right.	Fired into sand butt. Closed easily—two men; opened hard—two men. No escape of gas.	
55,000	1,711	O	....		Do.	
52,500	1,722	D	....		Do.	
52,000	1,717	O	....		Do.	
49,000	1,710	D	....		Closed easily—two men: opened hard—two men. No escape of gas. At 125th round lower V bolt, right side, broken.	
48,500	1,698	O	....		Closed easily—two men; opened hard—two men. No escape of gas. At 126th round cap bolt—breech block—broken; replaced.	
					Two quarts oil put in cylinder.	
67,000	1,669	D	....		Closed easily—two men.	

At 127th round gun burst explosively, destroying top carriage, breaking hydraulic cylinder, and shattering wooden casemates in which it was mounted. The pressure plug was found 26 feet to the rear and under the sand-crib placed in rear of the gun to catch pieces in case it should burst.

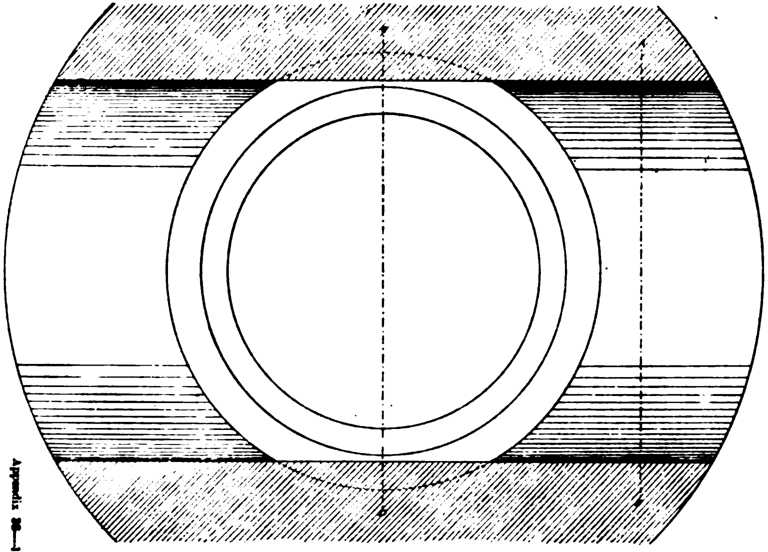
PLATE I.

8 INCH B. L. RIFLE—Chambered.

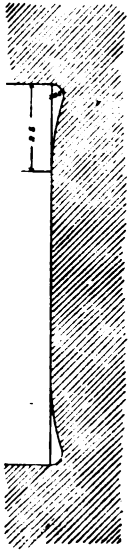
Showing method of rounding angles at front of Slot.

Scale 1/2.

Cross-section through Breech Reciever near front of Slot.



Section on A.B.



Section on C.D.

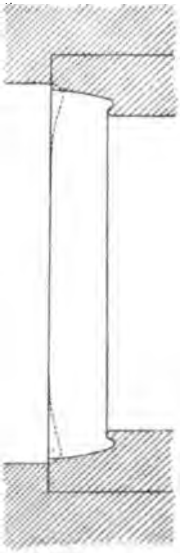
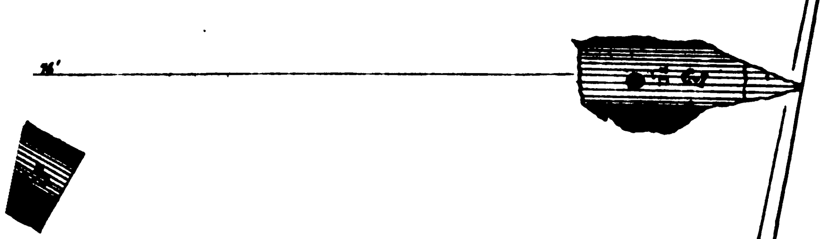


PLATE II.

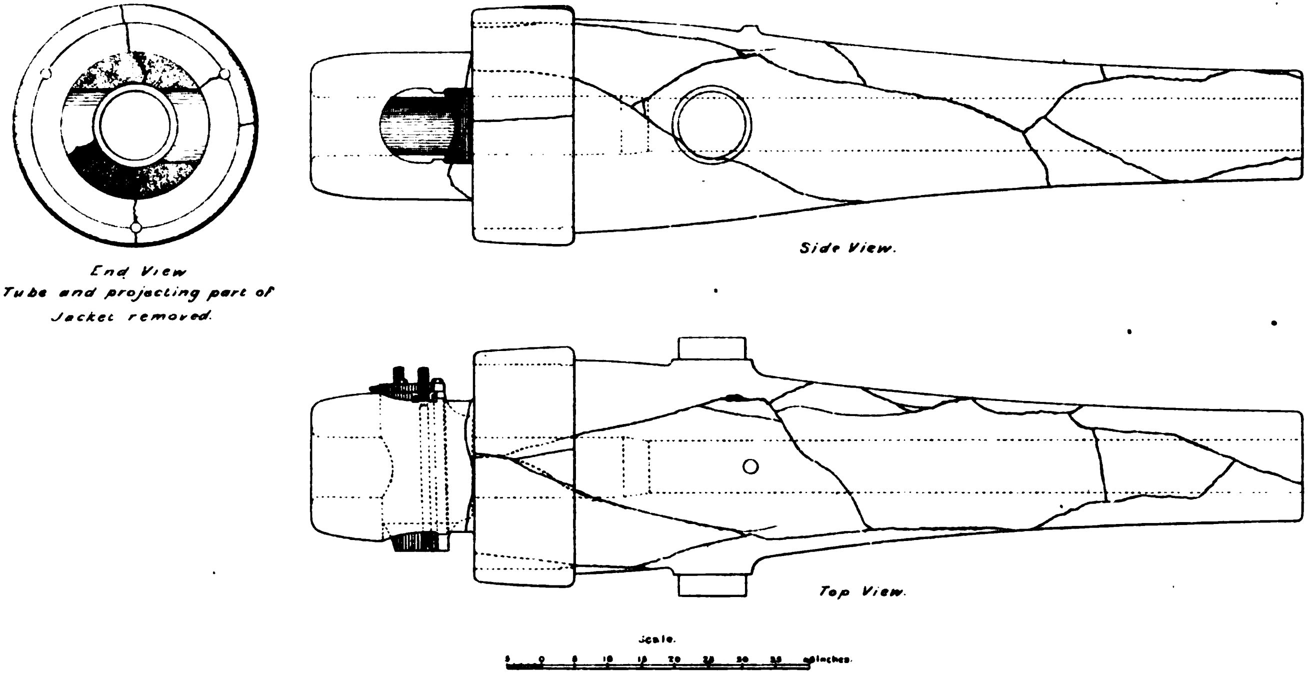


Appendix 36—1862.

PLATE IV.

8 INCH B.L. CHAMBERED RIFLE SHOWING LINES OF FRACTURE ON CASING

(GUN No. 2)



End View
Tube and projecting part of
Jacket removed.

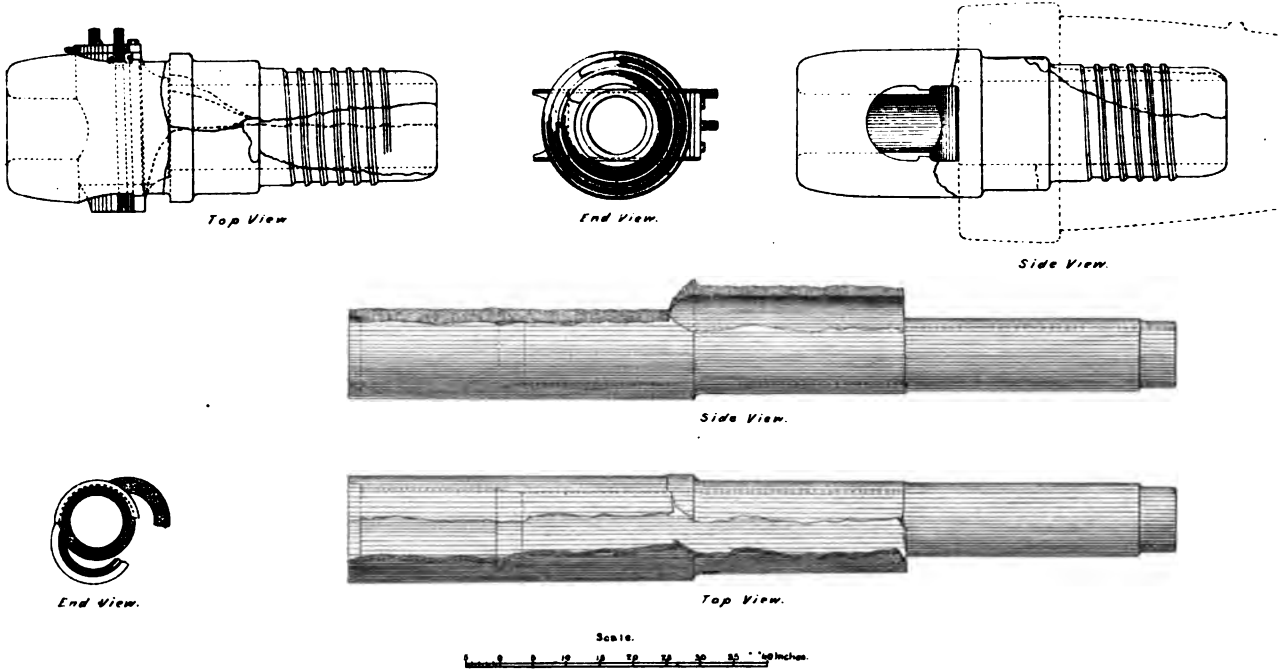
Side View.

Top View.

PLATE V.

8 INCH B. L. CHAMBERED RIFLE, SHOWING LINES OF FRACTURE ON JACKET AND TUBE.

(GUN Nº 2)



APPENDIX 37.

REPORT ON THE STEEL FOR 12-INCH BREECH-LOADING GUNS AND MORTAR HOWITZERS.

THE ORDNANCE BOARD, UNITED STATES ARMY,
New York City, December 9, 1881.

SIR: In accordance with paragraph 6, Special Orders No. 271, current series, dated Adjutant-General's Office, Washington, December 1, inst., the Board proceeded to Cold Spring and Boston and examined the Firth steel furnished by the contractors for the breech-receivers of the 12-inch breech-loading rifled mortar and the 12 inch breech-loading rifled guns. The contract between the United States and the founders for this steel requires "that in physical qualities the steel used shall fully equal the Whitworth fluid compressed steel employed in the fabrication of the 8-inch breech-loading rifle (converted) No. 1."

The comparative qualities of the steel furnished by Messrs. Firth & Co. to the contractors and the Whitworth steel are shown in a table inclosed herewith and appended to Captain Bryant's report. From this it appears that the physical characteristics of the Firth steel are below those of the standard in every respect.

A specimen broken from a piece removed from the slot of one of the breech-receivers for a 12-inch rifle was examined. It shows a fine, close, crystalline structure up to within 2½ inches from the exterior surface. Beyond this point the crystals are coarser and the structure is more open. It was observed that in drilling for specimens the hardness diminished in a marked manner at a point from 2½ to three inches from the exterior surface towards the interior. These facts indicate that the useful effects of hammering commenced to lose their influence at about one-fourth the thickness of the walls from the exterior.

Specimens were taken from similar pieces and turned down to a suitable size for use in the testing-machine. In every case flaws were found towards the interior. Three extension specimens in course of preparation from breech-receiver No. 1 had to be rejected because numerous flaws occurred in such a way as to render them unfit to endure tensile strain. One of the tenacity specimens from the interior of the same receiver broke at a low strain and revealed a flaw. Specimens from breech-receivers Nos. 2 and 3 contained similar flaws, but as they did not occur upon the portions subjected to stress, and as (except in the single case above mentioned) no flaws appeared upon the fractured surfaces, it is not believed that they influenced the results of the physical tests.

These flaws would probably cause an inequality in the resistance of the breech-receivers to longitudinal strain, and would diminish to an extent which cannot be accurately estimated the resisting cross-section of the receivers.

The hardness of the metal is variable from the exterior to the interior; and the hardest metal having generally the least extensibility, the strain would be taken up unequally by the surface of least resistance.

Particular attention is invited to the low tenacity, elastic limit and extensibility of the Firth steel. It appears that its elastic limit is lower than that of the interior tube of wrought iron. The system of gun construction for which these breech-receivers were intended has heretofore required the use of a ductile tube of wrought iron surrounded by a less ductile receiver of steel, which in turn is inclosed in a still less ductile casing of cast iron. To use a steel having as low an elastic limit and ductility as that in the receivers furnished the contractors by Firth & Co. for the 12-inch rifles and howitzer would imperil, and perhaps condemn, the whole system of construction by the employment of imperfect material.

In view of all these facts, the Board is of opinion that the breech-receivers of Firth steel furnished to the contractors for the 12-inch rifles and howitzer should not be accepted.

Respectfully submitted.

T. G. BAYLOR,
Lieutenant-Colonel of Ordnance, President of the Board.
GEO. W. MCKEE,
Major of Ordnance.
CHARLES SHALER,
Captain of Ordnance.

CHIEF OF ORDNANCE, U. S. A.,
Washington, D. C.

SOUTH BOSTON FOUNDRY,
Boston, Mass., October 15, 1881.

SIR: I have the honor to submit the following report upon the steel parts for 12-inch B. L. chambered rifles which have been received by the South Boston Iron Company from the works of Firth & Co., Sheffield, England, having been ordered from that firm for the purpose of fulfilling the contract dated September 28, 1880.

There have been received at the present date complete sets of parts for three rifles, and a breech block and obturator-plate for the fourth.

The complete sets have been inspected with regard to their dimensions, and although they vary in some important particulars from the figures given in the drawing accompanying the contract, all contain sufficient stock to admit of their being finished in conformity with the dimensions given in the drawings of the rifles to which they are to be fitted.

The results of the tests of the physical properties of the steel are given in Table No. 1 herewith inclosed.

The specimens tested were from pieces drilled out from the breech-receivers, where the slot for the breech-block is made, and were taken in a direction at right angles with the axis.

Table No. 2 contains a comparison of a mean of the results given in Table No. 1 with those obtained from tests of the Whitworth steel used in the fabrication of 8-inch B. L. rifle No. 1 (converted), and shows conclusively that the physical qualities of the Firth steel are far below what is required by the terms of the contract. The pieces taken out from the breech-receivers for procuring the test specimens show the existence of several cavities and air-holes in that portion next to the bore. These are, however, mostly very small, and I cannot find that any appear on the surfaces of the bores.

In consideration of the facts above stated, I am unable to report that this steel meets the requirements of the contract.

The South Boston Iron Company inform me that it will probably be out of the question for them to procure any steel of better quality to replace the parts herein reported upon.

Very respectfully, your obedient servant,

CULLEN BRYANT,
Captain of Ordnance.

CONSTRUCTOR OF ORDNANCE,
United States Ordnance Agency, New York.

The following table shows the result of experiments with Firth's steel furnished for the jackets of 12-inch B. L. rifles Nos. 1, 2, and 3. A tenacity specimen was taken from the exterior and interior of each jacket, and two specimens were in all cases taken to determine extension, restoration, and permanent set, making four test specimens from each jacket. The specific gravity and hardness (*a*) are the mean results from all four specimens. The tenacity (*b*) is the mean of the tenacity specimens. The other physical characteristics (*c*) show the mean results obtained from the extension specimens.

TABLE No. 1.—*Mean mechanical properties of Firth's steel furnished for jackets of* 12-*inch B. L. rifles Nos.* 1, 2, *and* 3.

	No. 1.	No. 2.	No. 3.
(*a*) Specific gravity	7.8535	7.8494	7.8597
Hardness	10.0375	11.1490	11.1980
(*b*) Tenacity ....pounds	*74,433	81,851	78,653
(*c*) Elastic limits ....do	17,500	17,000	14,500
Ultimate resistance ....do	61,500	61,000	59,000
Extension per inch at elastic limit ....inch	0.0005	0.0006	0.0006
Ultimate extension per inch ....do	0.1821	0.1273	0.1574
Ultimate restoration per inch ....do	0.00175	0.00305	0.00455
Ultimate permanent set ....do	0.18035	0.12430	0.15290
Mean area of specimens ....square inch	0.332	0.332	0.336
Length of specimens ....inch	10	10	10

* A single result from the exterior specimen, as the interior specimen exhibited a flaw and broke at 54,078 pounds.

TABLE No. 2.—*Mean mechanical properties of Firth's steel, furnished for jackets of* 12-*inch breech-loading rifles Nos.* 1, 2, *and* 3, *compared with those of Whitworth's fluid-compressed steel, furnished for* 8-*inch breech-loading rifle No.* 1, *converted.*

	(1) Whitworth's steel.	(2) Firth's steel.	Excess of (1) over (2).
(*a*) Specific gravity	7.8550	7.8542	0.0028
Hardness	16.2300	10.7918	5.4382
(*b*) Tenacity ....pounds	110,000	78,312	31,688
(*c*) Elastic limit ....do	38,500	16,333	22,167
Ultimate resistance ....do	86,000	60,500	24,500
Extension per inch at elastic limit ....inch	0.00230	0.00056	0.00174
Ultimate extension per inch ....do	0.17500	*0.11560	0.01940
Ultimate restoration per inch ....do	0.00352	0.00312	0.00040
Ultimate permanent set ....do	0.17149	0.15252	0.01897
Mean area of specimens ....square inch	0.343	0.333	0.010
Length of specimens ....inches	10	10	....

* Observation made before the weight which caused rupture was applied.

Table showing tenacity, hardness, and specific gravity of tenacity specimens taken from exterior and interior of jackets for 12-inch breech-loading rifles, Nos. 1, 2, 3.

Characteristics, &c.	No. 1.		No. 2.		No. 3.	
	Exterior.	Interior.	Exterior.	Interior.	Exterior.	Interior.
Original area	33, 285	33, 285	32, 675	33, 490	33, 388	33, 3[illegible]
Weight applied	24, 775	*18, 000	27, 500	26, 475	26, 850	25, 7[illegible]
Weight for one square inch area	74, 433	54, 078	84, 162	79, 540	80, 418	76, [illegible]
Weight applied for hardness	10, 000	10, 000	10, 000	10, 000	10, 000	10, 000
Length of cut	6. 9	6. 95	6. 6	6. 7	6. 7	6. 7
Hardness	10. 146	9. 929	11. 594	11. 083	11. 063	11. 063
Specific gravity	7. 8348	7. 8722	7. 8694	7. 8497	7. 8765	7. 8[illegible]

* Flaw.

Table showing the extension, restoration, and permanent set caused by the undermentioned weights per square inch of the primitive section acting upon a solid cylinder 10 inches long and 0.650 inch in diameter, taken from piece removed from slot of jacket for 12-inch breech-loading rifle No. 1.

[Jacket 1, F. 2.]

Weight per square inch of original area.	Extension per inch in length.	Successive extension per inch in length.	Restoration per inch in length.	Successive restoration per inch in length.	Permanent set per inch in length.	Successive permanent set per inch in length.
Pounds.	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
1, 000	.0000	.0000	.0000	.0000	.0000	.0000
2, 100	.0000	.0000	.0000	.0000	.0000	.0000
3, 000	.0000	.0000	.0000	.0000	.0000	.0000
4, 000	.0001	.0001	.0001	.0001	.0000	.0000
5, 000	.0001	.0000	.0001	.0000	.0000	.0000
6, 000	.0002	.0001	.0002	.0001	.0000	.0000
7, 000	.0002	.0000	.0002	.0000	.0000	.0000
8, 000	.0002	.0000	.0002	.0000	.0000	.0000
9, 000	.0002	.0000	.0002	.0000	.0000	.0000
10, 000	.0003	.0001	.0003	.0001	.0000	.0000
11, 000	.0003	.0000	.0003	.0000	.0000	.0000
12, 000	.0004	.0001	.0004	.0001	.0000	.0000
13, 000	.0004	.0000	.0004	.0000	.0000	.0000
14, 000	.00045	.00005	.00045	.00005	.0000	.0000
15, 000	.0005	.00005	.0005	.00005	.0000	.0000
16, 000	.0006	.0001	.0006	.0001	.0000	.0000
17, 000	.0007	.0001	.0006	.0000	.0001	.0001
18, 000	.0009	.0002	.0007	.0001	.0002	.0001
19, 000	.0012	.0003	.0007	.0000	.0005	.0003
20, 000	.0017	.0005	.0007	.0000	.0010	.0005
21, 000	.0025	.0008	.0008	.0001	.0017	.0007
22, 000	.0031	.0006	.0008	.0000	.0023	.0006
23, 000	.0037	.0006	.0000	.0002	.0027	.0004
24, 000	.0047	.0010	.0008	—.0002	.0039	.0012
25, 000	.0057	.0010	.0010	.0002	.0047	.0008
26, 000	.0065	.0008	.0010	.0000	.0055	.0008
27, 000	.0077	.0012	.0010	.0000	.0067	.0012
28, 000	.0088	.0011	.0011	.0001	.0077	.0010
29, 000	.0096	.0008	.0011	.0000	.0085	.0008
30, 000	.0107	.0011	.0012	.0001	.0095	.0010
31, 000	.0125	.0018	.0013	.0001	.0112	.0017
32, 000	.0135	.0010	.0013	.0000	.0122	.0010
33, 000	.0148	.0013	.0014	.0001	.0134	.0012
34, 000	.0162	.0014	.0015	.0001	.0147	.0013
35, 000	.0177	.0015	.0015	.0000	.0162	.0015
36, 000	.0189	.0012	.0015	.0000	.0174	.0012
37, 000	.0204	.0015	.0016	.0001	.0188	.0014
38, 000	.0219	.0015	.0017	.0001	.0202	.0014
39, 000	.0238	.0019	.0018	.0001	.0220	.0018
40, 000	.0257	.0019	.0017	—.0001	.0240	.0020
41, 000	.0274	.0017	.0018	.0001	.0256	.0016
42, 000	.0297	.0023	.0020	.0002	.0277	.0021
43, 000	.0316	.0019	.0019	.0001	.0297	.0020
44, 000	.0339	.0023	.0020	.0001	.0319	.0022
45, 000	.0362	.0023	.0020	.0000	.0342	.0023
46, 000	.0399	.0028	.0021	.0001	.0369	.0027

Table showing the extension, restoration, and permanent set, &c.—Continued.

Weight per square inch of original area.	Extension per inch in length.	Successive extension per inch in length.	Restoration per inch in length.	Successive restoration per inch in length.	Permanent set per inch in length.	Successive permanent set per inch in length.
Pounds.	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
47, 000	.0418	.0028	.0025	.0004	.0393	.0024
48, 000	.0442	.0024	.0022	—.0003	.0420	.0027
49, 000	.0497	.0037	.0022	.0000	.0457	.0037
50, 000	.0512	.0033	.0022	.0000	.0490	.0033
51, 000	.0557	.0045	.0025	.0003	.0532	.0042
52, 000	.0603	.0046	.0025	.0000	.0578	.0046
53, 000	.0651	.0038	.0026	.0001	.0625	.0047
54, 000	.0709	.0058	.0026	.0000	.0683	.0058
55, 000	.0789	.0080	.0027	.0001	.0762	.0079
56, 000	.0869	.0080	.0029	.0002	.0840	.0078
57, 000	.0962	.0093	.0030	.0001	.0932	.0092
58, 000	.1092	.0130	.0033	.0003	.1059	.0127
59, 000	.1223	.0131	.0030	.0003	.1193	.0134
60, 000	.1537	.0314	.0037	.0007	.1500	.0307
61, 000	.1812	.0275	.0020	—.0017	.1792	.0292
62, 000	......	......	......	......	......	......
63, 000	......	......	......	......	......	......
64, 000	......	......	......	......	......	......
65, 000	......	......	......	......	......	......
66, 000	......	......	......	......	......	......
67, 000	......	......	......	......	......	......
68, 000	......	......	......	......	......	......
69, 000	......	......	......	......	......	......
70, 000	......	......	......	......	......	......
71, 000	......	......	......	......	......	......
72, 000	......	......	......	......	......	......
73, 000	......	......	......	......	......	......
74, 000	......	......	......	......	......	......
75, 000	......	......	......	......	......	......
76, 000	......	......	......	......	......	......
77, 000	......	......	......	......	......	......
78, 000	......	......	......	......	......	......
79, 000	......	......	......	......	......	......
80, 000	......	......	......	......	......	......
81, 000	......	......	......	......	......	......
82, 000	......	......	......	......	......	......
83, 000	......	......	......	......	......	......
84, 000	......	......	......	......	......	......
85, 000	......	......	......	......	......	......
86, 000	......	......	......	......	......	......

GENERAL SUMMARY.

Specific gravity		
Original of cross-section	**sq. inch..**	**0. 3318**
Elastic limit	**pounds..**	**16, 000**
Extension per inch at rupture	**inch..**	**0. 1812**
Ultimate resistance per square inch of original area	**pounds..**	**62, 000**
Reduction in diameter at point of rupture	**inch..**	.055
Ratio of elastic to ultimate resistance		
Contraction in area at fracture	**per cent..**	
Area after rupturé	**sq. inch..**	**.2781**
Position of rupture		**1″.5 from upper shoulder.**
Character of surface		**crystalline, medium, coarse.**

Table showing the extension, restoration, and permanent set caused by the under-mentioned weights per square inch of the primitive section acting upon a solid cylinder 10 inches long and 0.653 inch in diameter, taken from piece removed from slot of jacket for 12 inch breech-loading rifle No. 1.

[Jacket 1, F 1.]

Weight per square inch of original area.	Extension per inch in length.	Successive extension per inch in length.	Restoration per inch in length.	Successive restoration per inch in length.	Permanent set per inch in length.	Successive permanent set per inch in length.
Pounds.	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
1, 000	.00000	.00000	.00000	.00000	.0000	.0000
2, 000	.00000	.00000	.00000	.00000	.0000	.0000
3, 000	.00000	.00000	.00000	.00000	.0000	.0000
4, 000	.00000	.00000	.00000	.00000	.0000	.0000
5, 000	.00000	.00000	.00000	.00000	.0000	.0000
6, 000	.00000	.00000	.00000	.00000	.0000	.0000
7, 000	.00000	.00000	.00000	.00000	.0000	.0000
8, 000	.00000	.00000	.00000	.00000	.0000	.0000
9, 000	.00000	.00000	.00000	.00000	.0000	.0000
10, 000	.00005	.00005	.00005	.00005	.0000	.0000
11, 000	.00005	.00000	.00005	.00000	.0000	.0000
12, 000	.00006	.00001	.00006	.00001	.0000	.0000
13, 000	.00008	.00002	.00008	.00002	.0000	.0000
14, 000	.00010	.00002	.00010	.00002	.0000	.0000
15, 000	.00015	.00005	.00015	.00005	.0000	.0000
16, 000	.00020	.00005	.00020	.00005	.0000	.0000
17, 000	.0002	.0000	.0002	.0000	.0000	.0000
18, 000	.0003	.0001	.0003	.0001	.0000	.0000
19, 000	.0004	.0001	.0004	.0001	.0000	.0000
20, 000	.0012	.0008	.0006	.0002	.0006	.0006
21, 000	.0017	.0005	.0007	.0001	.0010	.0004
22, 000	.0037	.0020	.0008	.0001	.0029	.0019
23, 000	.0039	.0002	.0008	.0000	.0031	.0002
24, 000	.0043	.0004	.0009	.0001	.0034	.0003
25, 000	.0050	.0007	.0010	.0001	.0040	.0006
26, 000	.0062	.0012	.0009	—.0001	.0053	.0013
27, 000	.0070	.0008	.0010	.0001	.0060	.0007
28, 000	.0081	.0011	.0010	.0000	.0071	.0011
29, 000	.0094	.0011	.0010	.0000	.0084	.0011
30, 000	.0106	.0012	.0012	.0002	.0094	.0010
31, 000	.0117	.0011	.0012	.0000	.0105	.0011
32, 000	.0133	.0016	.0013	.0001	.0120	.0015
33, 000	.0145	.0012	.0014	.0001	.0131	.0011
34, 000	.0157	.0012	.0015	.0001	.0142	.0011
35, 000	.0173	.0016	.0015	.0000	.0158	.0016
36, 000	.0185	.0012	.0015	.0000	.0170	.0012
37, 000	.0202	.0017	.0016	.0001	.0186	.0016
38, 000	.0220	.0018	.0017	.0001	.0203	.0017
39, 000	.0234	.0014	.0017	.0000	.0217	.0014
40, 000	.0255	.0021	.0018	.0001	.0237	.0020
41, 000	.0272	.0017	.0018	.0000	.0254	.0017
42, 000	.0292	.0020	.0020	.0002	.0272	.0018
43, 000	.0316	.0024	.0020	.0000	.0296	.0024
44, 000	.0337	.0021	.0019	—.0001	.0318	.0022
45, 000	.0362	.0025	.0021	.0002	.0341	.0023
46, 000	.0388	.0026	.0012	—.0009	.0372	.0031
47, 000	.0420	.0032	.0020	.0008	.0400	.0028
48, 000	.0449	.0029	.0022	.0002	.0427	.0027
49, 000	.0484	.0035	.0024	.0002	.0460	.0033
50, 000	.0518	.0034	.0013	—.0011	.0495	.0035
51, 000	.0559	.0041	.0019	.0006	.0540	.0045
52, 000	.0606	.0047	.0026	.0007	.0580	.0040
53, 000	.0655	.0049	.0026	.0000	.0629	.0049
54, 000	.0712	.0057	.0027	.0001	.0685	.0056
55, 000	.0775	.0063	.0028	.0001	.0747	.0062
56, 000	.0878	.0193	.0028	.0000	.0850	.0103
57, 000	.0980	.0102	.0029	.0001	.0951	.0101
58, 000	.1110	.0130	.0031	.0002	.1079	.0128
59, 000	.1275	.0165	.0034	.0003	.1241	.0162
60, 000	.1830	.0555	.0015	—.0019	.1815	.0574
61, 000	....	....	....	....	....	....
62, 000	....	....	....	....	....	....
63, 000	....	....	....	....	....	....
64, 000	....	....	....	....	....	....
65, 000	....	....	....	....	....	....
66, 000	....	....	....	....	....	....
67, 000	....	....	....	....	....	....
68, 000	....	....	....	....	....	....
69, 000	....	....	....	....	....	....
70, 000	....	....	....	....	....	....
71, 000	....	....	....	....	....	....
72, 000	....	....	....	....	....	....
73, 000	....	....	....	....	....	....

Table showing the extension, restoration, and permanent set, &c.—Continued.

Weight per square inch of original area.	Extension per inch in length.	Successive extension per inch in length.	Restoration per inch in length.	Successive restoration per inch in length.	Permanent set per inch in length.	Successive permanent set per inch in length.
Pounds.	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
74, 000	....	....	....	....	....	....
75, 000	....	....	....	....	....	....
76, 000	....	....	....	....	....	....
77, 000	....	....	....	....	....	....
78, 000	....	....	....	....	....	....
79, 000	....	....	....	....	....	....
80, 000	....	....	....	....	....	....
81, 000	....	....	....	....	....	....
82, 000	....	....	....	....	....	....
83, 000	....	....	....	....	....	....
84, 000	....	....	....	....	....	....
85, 000	....	....	....	....	....	....
86, 000	....	....	....	....	....	....

GENERAL SUMMARY.

Specific gravity		
Hardness		
Elastic limit	pounds..	19, 000
Extension per inch at rupture	inch..	0. 1830
Ultimate resistance per square inch of original area	pounds..	61, 000
Reduction in diameter at point of rupture	inch..	0. 110
Original area of cross-section	sq. inch..	. 3349
Area after rupture	sq. inch..	. 2316
Ultimate resistance per square inch of fractured area	pounds..	
Position of rupture		near center.
Character of surface		crystalline, medium coarse.

Table showing the extension, restoration, and permanent set caused by the undermentioned weights per square inch of the primitive section acting upon a solid cylinder 9.990 *inches long and* 0.651 *inch in diameter, taken from piece removed from slot of jacket for* 12-*inch breech-loading rifle No.* 2.

[Jacket 2, September 8, 1881.]

Weight per square inch of original area.	Extension per inch in length.	Successive extension per inch in length.	Restoration per inch in length.	Successive restoration per inch in length.	Permanent set per inch in length.	Successive permanent set per inch in length.
Pounds.	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
1, 000	. 0001	....	. 0001	....	. 0000	....
2, 000	. 0001	. 0000	. 0001	. 0000	. 0000	. 0000
3, 000	. 0002	. 0001	. 0002	. 0001	. 0000	. 0000
4, 000	. 0002	. 0000	. 0002	. 0000	. 0000	. 0000
5, 000	. 0002	. 0000	. 0002	. 0000	. 0000	. 0000
6, 000	. 0002	. 0000	. 0002	. 0000	. 0000	. 0000
7, 000	. 0002	. 0000	. 0002	. 0000	. 0000	. 0000
8, 000	. 0003	. 0001	. 0003	. 0001	. 0000	. 0000
9, 000	. 0003	. 0000	. 0003	. 0000	. 0000	. 0000
10, 000	. 0003	. 0000	. 0003	. 0000	. 0000	. 0000
11, 000	. 0004	. 0001	. 0004	. 0001	. 0000	. 0000
12, 000	. 0004	. 0000	. 0004	. 0000	. 0000	. 0000
13, 000	. 0004	. 0000	. 0004	. 0000	. 0000	. 0000
14, 000	. 0004	. 0000	. 0004	. 0000	. 0000	. 0000
15, 000	. 0005	. 0001	. 0005	. 0001	. 0000	. 0000
16, 000	. 0005	. 0000	. 0005	. 0000	. 0000	. 0000
17, 000	. 0006	. 0001	. 0004	—. 0001	. 0002	. 0002
18, 000	. 0010	. 0004	. 0006	. 0002	. 0004	. 0002
19, 000	. 0026	. 0016	. 0016	. 0010	. 0010	. 0006
20, 000	. 0031	. 0005	. 0018	. 0002	. 0013	. 0003
21, 000	. 0034	. 0003	. 0006	—. 0012	. 0028	. 0015
22, 000	. 0042	. 0008	. 0007	. 0001	. 0035	. 0007
23, 000	. 0052	. 0010	. 0008	. 0001	. 0044	. 0009
24, 000	. 0062	. 0010	. 0008	. 0000	. 0054	. 0010
25, 000	. 0073	. 0011	. 0009	. 0001	. 0064	. 0010
26, 000	. 0081	. 0008	. 0010	. 0001	. 0071	. 0007
27, 000	. 0095	. 0014	. 0015	. 0005	. 0080	. 0009
28, 000	. 0104	. 0009	. 0011	—. 0004	. 0093	. 0013
29, 000	. 0121	. 0017	. 0012	. 0001	. 0109	. 0016

Table showing the extension, restoration, and permanent set, &c.—Continued.

Weight per square inch of original area.	Extension per inch in length.	Successive extension per inch in length.	Restoration per inch in length.	Successive restoration per inch in length.	Permanent set per inch in length.	Succe- perma- set per in len-
Pounds.	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*In*
30,000	.0131	.0010	.0012	.0000	.0119	[illegible]
31,000	.0151	.0020	.0014	.0002	.0137	[illegible]
32,000	.0161	.0010	.0013	—.0001	.0148	[illegible]
33,000	.0176	.0015	.0013	.0000	.0163	[illegible]
34,000	.0193	.0017	.0015	.0002	.0178	[illegible]
35,000	.0204	.0011	.0014	—.0001	.0190	[illegible]
36,000	.0228	.0024	.0016	.0002	.0212	[illegible]
37,000	.0241	.0013	.0017	.0001	.0224	[illegible]
38,000	....	....	....	....	....	....
39,000	....	....	....	....	....	....
40,000	....	....	....	....	....	....
41,000	....	....	....	....	....	....
42,000	....	....	....	....	....	....
43,000	....	....	....	....	....	....
44,000	....	....	....	....	....	....
45,000	....	....	....	....	....	....
46,000	....	....	....	....	....	....
47,000	....	....	....	....	....	....
48,000	....	....	....	....	....	....
49,000	.0669	....	.0025	....	.0644	....
50,000	.0672	.0002	.0024	—.0001	.0648	[illegible]
51,000	.0681	.0009	.0025	.0001	.0656	[illegible]
52,000	.0723	.0042	.0026	.0001	.0697	[illegible]
53,000	.0797	.0074	.0025	—.0001	.0772	[illegible]
54,000	.0893	.0096	.0028	.0003	.0865	[illegible]
55,000	.1044	.0151	.0030	.0002	.1014	.01
56,000	.1219	.0175	.0030	.0000	.1189	.01
57,000	....	....	....	....	....	....
58,000	....	....	....	....	....	....
59,000	....	....	....	....	....	....
60,000	....	....	....	....	....	....
61,000	....	....	....	....	....	....
62,000	....	....	....	....	....	....
63,000	....	....	....	....	....	....
64,000	....	....	....	....	....	....
65,000	....	....	....	....	....	....
66,000	....	....	....	....	....	....
67,000	....	....	....	....	....	....
68,000	....	....	....	....	....	....
69,000	....	....	....	....	....	....
70,000	....	....	....	....	....	....
71,000	....	....	....	....	....	....
72,000	....	....	....	....	....	....
73,000	....	....	....	....	....	....
74,000	....	....	....	....	....	....
75,000	....	....	....	....	....	....
76,000	....	....	....	....	....	....
77,000	....	....	....	....	....	....
78,000	....	....	....	....	....	....
79,000	....	....	....	....	....	....
80,000	....	....	....	....	....	....
81,000	....	....	....	....	....	....
82,000	....	....	....	....	....	....
83,000	....	....	....	....	....	....
84,000	....	....	....	....	....	....
85,000	....	....	....	....	....	....
86,000	....	....	....	....	....	....

GENERAL SUMMARY.

Specific gravity ....
Hardness ....
Elastic limit ....pounds..
Extension per inch at rupture ....inch..
Ultimate resistance per square inch of original area ....pounds..
Reduction in diameter at point of rupture ....inch..
Original area of cross-section ....square inch..
Area after rupture ....do....
Ultimate resistance per square inch of fractured area ....pounds..
Position of rupture ....near c
Character of surface ....mixed, fibrous, and cry

able showing the extension, restoration, and permanent set caused by the undermentioned weights per square inch of the primitive section acting upon a solid cylinder 10 *inches long and* 0.650 *inch in diameter, taken from front of piece removed from slot of jacket for* 12-*inch breech-loading rifle.*

[Jacket 2, F 1.]

Weight per quare inch of original area.	Extension per inch in length.	Successive extension per inch in length.	Restoration per inch in length.	Successive restoration per inch in length.	Permanent set per inch in length.	Successive permanent set per inch in length.
Pounds.	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
1,000	.0000	....	.0001	....	.0000	....
2,000	.0001	.0000	.0001	.0000	.0000	....
3,000	.0001	.0000	.0001	.0000	.0000	....
4,000	.0001	.0000	.0001	.0000	.0000	....
5,000	.0001	.0000	.0001	.0000	.0000	....
6,000	.0002	.0000	.0002	.0001	.0000	....
7,000	.0002	.0000	.0002	.0000	.0000	....
8,000	.0008	.0000	.0003	.0001	.0000	....
9,000	.0003	.0000	.0003	.0000	.0000	....
10,000	.0004	.0001	.0004	.0000	.0000	....
11,000	.0005	.0001	.0005	.0001	.0000	....
12,000	.0005	.0000	.0005	.0000	.0000	....
13,000	.0005	.0000	.0005	.0000	.0000	....
14,000	.0005	.0000	.0005	.0000	.0000	....
15,000	.0005	.0000	.0005	.0000	.0000	....
16,000	.0005	.0000	.0005	.0000	.0000	....
17,000	.0006	.0001	.0006	.0001	.0000	....
18,000	.0007	.0001	.0007	.0001	.0000	....
19,000	.0010	.0003	.0008	.0001	.0002	.0002
20,000	.0011	.0001	.0006	—.0002	.0005	.0003
21,000	.0016	.0005	.0007	.0001	.0009	.0004
22,000	.0025	.0009	.0008	.0001	.0017	.0008
23,000	.0035	.0010	.0008	.0000	.0027	.0010
24,000	.0040	.0005	.0007	—.0001	.0033	.0006
25,000	.0047	.0007	.0004	—.0003	.0043	.0010
26,000	.0068	.0020	.0020	.0016	.0048	.0005
27,000	.0075	.0007	.0012	—.0008	.0063	.0015
28,000	.0073	.0003	.0010	—.0002	.0068	.0005
29,000	.0090	.0012	.0012	.0002	.0078	.0010
30,000	.0103	.0013	.0010	—.0002	.0093	.0015
31,000	.0117	.0014	.0012	.0002	.0105	.0012
32,000	.0127	.0010	.0014	.0002	.0113	.0008
33,000	.0138	.0011	.0013	—.0001	.0125	.0012
34,000	.0148	.0010	.0014	.0001	.0134	.0009
35,000	.0165	.0017	.0015	.0001	.0150	.0016
36,000	.0177	.0011	.0016	.0001	.0161	.0011
37,000	.0192	.0015	.0015	—.0001	.0177	.0016
38,000	.0207	.0015	.0015	.0000	.0192	.0015
39,000	.0223	.0016	.0018	.0003	.0205	.0013
40,000	.0241	.0018	.0018	.0000	.0223	.0018
41,000	.0265	.0024	.0026	.0008	.0239	.0016
42,000	.0277	.0012	.0018	—.0008	.0259	.0020
43,000	.0293	.0016	.0018	.0000	.0275	.0016
44,000	.0322	.0029	.0020	.0002	.0302	.0027
45,000	.0343	.0021	.0020	.0000	.0323	.0021
46,000	.0368	.0025	.0020	.0000	.0348	.0025
47,000	.0389	.0021	.0021	.0001	.0368	.0020
48,000	.0425	.0036	.0022	.0001	.0403	.0035
49,000	.0452	.0027	.0022	.0000	.0430	.0027
50,000	.0485	.0033	.0022	.0000	.0463	.0033
51,000	.0522	.0037	.0022	.0006	.0500	.0037
52,000	.0558	.0037	.0023	.0001	.0535	.0035
53,000	.0601	.0043	.0024	.0001	.0577	.0042
54,000	.0653	.0052	.0026	.0002	.0627	.0050
55,000	.0712	.0059	.0025	—.0001	.0687	.0060
56,000	.0773	.0061	.0026	.0001	.0747	.0060
57,000	.0850	.0077	.0029	.0003	.0821	.0074
58,000	.0933	.0083	.0018	—.0011	.0915	.0094
59,000	.1070	.0137	.0030	.0015	.1040	.0125
60,000	.1328	.0258	.0031	.0001	.1297	.0157
61,000	....	....	....	....	....	....
62,000	....	....	....	....	....	....
63,000	....	....	....	....	....	....
64,000	....	....	....	....	....	....
65,000	....	....	....	....	....	....
66,000	....	....	....	....	....	....
67,000	....	....	....	....	....	....
68,000	....	....	....	....	....	....
69,000	....	....	....	....	....	....
70,000	....	....	....	....	....	....
71,000	....	....	....	....	....	....
72,000	....	....	....	....	....	....

Table showing extension, restoration, and permanent set, &c.—Continued.

Weight per square inch of original area.	Extension per inch in length.	Successive extension per inch in length.	Restoration per inch in length.	Successive restoration per inch in length.	Permanent set per inch in length.	Successive permanent set per inch in length.
Pounds.	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
73,000						
74,000						
75,000						
76,000						
77,000						
78,000						
79,000						
80,000						
81,000						
82,000						
83,000						
84,000						
85,000						
86,000						

GENERAL SUMMARY.

Specific gravity		7.8[illegible]
Hardness		11.0[illegible]
Tenacity	pounds	
Elastic limit	do	15.[illegible]
Extension per inch at rupture	inch	.13[illegible]
Ultimate resistance per square inch of original area	pounds	61.0[illegible]
Reduction in diameter at point of rupture	inch	.0[illegible]
Original area of cross-section	square inch	.33[illegible]
Area after rupture	do	.2[illegible]
Ultimate resistance per square inch of fractured area	pounds	
Position of rupture		1''.6 from shoulder
Character of surface		fine crystalline

Table showing the extension, restoration, and permanent set caused by the undermentioned weights per square inch of the primitive section acting upon a solid cylinder 10 *inches long and* .653 *inch in diameter, taken from piece removed from slot of jacket for* 12-*inch breech-loading rifle No.* 3.

[Jacket 3, September 8, 1881.]

Weight per square inch of original area.	Extension per inch in length.	Successive extension per inch in length.	Restoration per inch in length.	Successive restoration per inch in length.	Permanent set per inch in length.	Successive permanent set per inch in length.
Pounds.	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
1,000	.0001		.0001		.0000	
2,000	.0001	.0000	.0001	.0000	.0000	.0000
3,000	.0001	.0000	.0001	.0000	.0000	.0000
4,000	.0002	.0001	.0002	.0001	.0000	.0000
5,000	.0003	.0001	.0003	.0001	.0000	.0000
6,000	.0003	.0000	.0003	.0000	.0000	.0000
7,000	.0003	.0000	.0003	.0000	.0000	.0000
8,000	.0004	.0001	.0004	.0001	.0000	.0000
9,000	.0004	.0000	.0004	.0000	.0000	.0000
10,000	.0004	.0000	.0004	.0000	.0000	.0000
11,000	.0005	.0001	.0005	.0001	.0000	.0000
12,000	.0005	.0000	.0005	.0000	.0000	.0000
13,000	.0006	.0001	.0006	.0001	.0000	.0000
14,000	.0006	.0000	.0006	.0000	.0000	.0000
15,000	.0006	.0000	.0006	.0000	.0000	.0000
16,000	.0008	.0002	.0007	.0001	.0001	.0001
17,000	.0008	.0000	.0006	—.0001	.0002	.0001
18,000	.0009	.0001	.0006	.0000	.0003	.0001
19,000	.0013	.0004	.0008	.0002	.0005	.0002
20,000	.0017	.0004	.0007	—.0001	.0010	.0005
21,000	.0025	.0008	.0008	.0001	.0017	.0007
22,000	.0036	.0011	.0008	.0000	.0028	.0011
23,000	.0042	.0006	.0009	.0001	.0033	.0005
24,000	.0050	.0008	.0009	.0000	.0041	.0008
25,000	.0062	.0012	.0010	.0001	.0052	.0011
26,000	.0071	.0009	.0010	.0000	.0061	.0009
27,000	.0082	.0011	.0011	.0001	.0071	.0010
28,000	.0092	.0010	.0011	.0000	.0081	.0010

Table showing extension, restoration, and permanent set, &c.—Continued.

Weight per square inch of original area.	Extension per inch in length.	Successive extension per inch in length.	Restoration per inch in length.	Successive restoration per inch in length.	Permanent set per inch in length.	Successive permanent set per inch in length.
Pounds.	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
29, 000	.0103	.0010	.0012	.0001	.0090	.0009
30, 000	.0120	.0018	.0013	.0001	.0107	.0017
31, 000	.0128	.0008	.0012	—.0001	.0116	.0009
32, 000	.0140	.0012	.0014	.0002	.0126	.0010
33, 000	.0154	.0014	.0014	.0000	.0140	.0014
34, 000	.0173	.0023	.0015	.0001	.0158	.0018
35, 000	.0185	.0012	.0013	—.0002	.0172	.0014
36, 000	.0210	.0025	.0017	.0004	.0183	.0011
37, 000	.0218	.0008	.0015	—.0002	.0203	.0020
38, 000	.0230	.0012	.0015	.0000	.0215	.0012
39, 000	.0247	.0017	.0017	.0002	.0230	.0015
40, 000	.0273	.0026	.0018	.0001	.0255	.0025
41, 000	.0288	.0015	.0018	.0000	.0270	.0015
42,000	.0311	.0023	.0016	—.0002	.0295	.0025
43, 000	.0358	.0027	.0018	.0002	.0320	.0025
44, 000	.0358	.0028	.0018	.0000	.0340	.0020
45, 000	.0392	.0034	.0020	.0002	.0372	.0032
46, 000	.0415	.0023	.0022	.0002	.0393	.0021
47, 000	.0447	.0002	.0020	—.0002	.0427	.0084
48, 000	.0482	.0035	.0022	.0002	.0460	.0023
49, 000	.0541	.0059	.0022	.0000	.0519	.0059
50, 000	.0565	.0024	.0025	.0003	.0540	.0021
51, 000	.0613	.0048	.0023	—.0002	.0590	.0050
52, 000	.0670	.0057	.0025	.0002	.0645	.0055
53, 000	.0730	.0060	.0026	.0001	.0704	.0059
54, 000	.0867	.0137	.0027	.0001	.0840	.0136
55, 000	.0992	.0125	.0027	.0000	.0865	.0025
56, 000	.1020	.0028	.0028	.0001	.0992	.0027
57, 000	.1160	.0140	.0029	.0001	.1131	.0139
58, 000	.1526	.0366	.0026	—.0003	.1500	.0369
59, 000	(*)	(*)	(*)	(*)	(*)	(*)
60, 000	....	....	....	....	....	....
61, 000	....	....	....	....	....	....
62, 000	....	....	....	....	....	....
63, 000	....	....	....	....	....	....
64, 000	....	....	....	....	....	....
65, 000	....	....	....	....	....	....
66, 000	....	....	....	....	....	....
67, 000	....	....	....	....	....	....
68, 000	....	....	....	....	....	....
69, 000	....	....	....	....	....	....
70, 000	....	....	....	....	....	....
71, 000	....	....	....	....	....	....
72, 000	....	....	....	....	....	....
73, 000	....	....	....	....	....	....
74, 000	....	....	....	....	....	....
75, 000	....	....	....	....	....	....
76, 000	....	....	....	....	....	....
77, 000	....	....	....	....	....	....
78, 000	....	....	....	....	....	....
79, 000	....	....	....	....	....	....
80, 000	....	....	....	....	....	....
81, 000	....	....	....	....	....	....
82, 000	....	....	....	....	....	....
83, 000	....	....	....	....	....	....
84, 000	....	....	....	....	....	....
85, 000	....	....	....	....	....	....
86, 000	....	....	....	....	....	....

GENERAL SUMMARY.

Specific gravity		†7.7624
Hardness		9.913
Elastic limit	pounds..	15,000
Extension per inch at rupture	inch..	.1526
Ultimate resistance per square inch of original area	pounds..	59,000
Reduction in diameter at point of rupture	inch..	128
Original at area of cross-section	square inch..	.33490
Contraction in area at fracture	per cent	....
Ultimate resistance per square inch of fractured area	pounds	....
Position of rupture		near center
Character of surface		fine crystalline and fibrous.

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* Specimen breaks.

† A seamy flaw existed in this specimen, which probably prevented an accurate estimation of specific gravity.

Table showing the extension, restoration, and permanent set caused by the undermentioned weights per square inch of primitive section acting upon a solid cylinder 10 inches long and .654 inch in diameter, taken from piece removed from slot of jacket for 12-inch breech-loading rifle No. 3.

[Jacket 3, F. 1, September 8, 1881.]

Weight per square inch of original area.	Extension per inch in length.	Successive extension per inch in length.	Restoration per inch in length.	Successive restoration per inch in length.	Permanent set per inch in length.	Successive permanent set per inch in length.
Pounds.	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*	*Inch.*
1,000	.0001	....	.0001	....	.0000	....
2,000	.0001	.0000	.0001	.0000	.0000	.0000
3,000	.0002	.0001	.0002	.0001	.0000	.0000
4,000	.0003	.0001	.0003	.0001	.0000	.0000
5,000	.0003	.0000	.0003	.0000	.0000	.0000
6,000	.0003	.0000	.0003	.0000	.0000	.0000
7,000	.0003	.0000	.0003	.0000	.0000	.0000
8,000	.0003	.0000	.0003	.0000	.0000	.0000
9,000	.0004	.0001	.0004	.0001	.0000	.0000
10,000	.0004	.0000	.0004	.0000	.0000	.0000
11,000	.0004	.0000	.0004	.0000	.0000	.0000
12,000	.0005	.0001	.0005	.0001	.0000	.0000
13,000	.0006	.0001	.0006	.0001	.0000	.0000
14,000	.0006	.0000	.0006	.0000	.0000	.0000
15,000	.0006	.0000	.0005	—.0001	.0001	.0001
16,000	.0007	.0001	.0005	.0000	.0002	.0001
17,000	.0009	.0002	.0006	.0001	.0003	.0001
18,000	.0012	.0003	.0008	.0002	.0004	.0001
19,000	.0015	.0003	.0007	—.0001	.0008	.0004
20,000	.0026	.0011	.0008	.0001	.0018	.0010
21,000	.0035	.0009	.0008	.0000	.0027	.0009
22,000	.0045	.0010	.0009	.0001	.0036	.0009
23,000	.0053	.0008	.0008	—.0001	.0045	.0009
24,000	.0060	.0007	.0009	.0001	.0051	.0006
25,000	.0074	.0014	.0008	—.0001	.0066	.0015
26,000	.0085	.0011	.0010	.0002	.0075	.0009
27,000	.0097	.0012	.0012	.0002	.0085	.0010
28,000	.0105	.0008	.0012	.0000	.0093	.0008
29,000	.0121	.0006	.0013	.0001	.0108	.0015
30,000	.0135	.0014	.C013	.0000	.0122	.0014
31,000	.0147	.0012	.0014	.0001	.0133	.0011
32,000	.0157	.0010	.0013	—.0001	.0144	.0011
33,000	.0176	.0019	.0016	.0003	.0160	.0016
34,000	.0192	.0016	.0017	.0001	.0175	.0015
35,000	.0202	.0010	.0014	—.0003	.0188	.0013
36,000	.0226	.0024	.0015	.0001	.0211	.0023
37,000	.0240	.0014	.0017	.0002	.0223	.0012
38,000	.0257	.0017	.0017	.0000	.0240	.0017
39,000	.0278	.0021	.0018	.0001	.0260	.0020
40,000	.0283	.0005	.0018	.0000	.0265	.0005
41,000	.0321	.0038	.0021	.0003	.0300	.0035
42,000	.0331	.0010	.0019	—.0002	.0312	.0012
43,000	.0366	.0036	.0019	.0000	.0347	.0035
44,000	.0380	.0014	.0019	.0000	.0361	.0014
45,000	.0420	.0040	.0020	.0001	.0400	.0039
46,000	.0442	.0022	.0019	—.0001	.0423	.0023
47,000	.0480	.0038	.0022	.0003	.0458	.0035
48,000	.0516	.0036	.0020	—.0002	.0496	.0038
49,000	.0552	.0036	.0022	.0002	.0530	.0034
50,000	.0601	.0049	.0023	.0001	.0578	.0048
51,000	.0645	.0044	.0024	.0001	.0621	.0043
52,000	.0705	.0050	.0023	—.0001	.0682	.0061
53,000	.0771	.0066	.0024	.0001	.0747	.0065
54,000	.0853	.0052	.0020	—.0004	.0838	.0086
55,000	.0940	.0087	.0025	.0001	.0915	.0082
56,000	.1117	.0177	.0026	.0001	.1091	.0176
57,000	.1275	.0158	.0027	.0001	.1248	.0157
58,000	.1623	.0348	.0065	.0038	.1558	.0310
59,000	(*)	(*)	(*)	(*)	(*)	(*)

* Specimen breaks.

GENERAL SUMMARY.

Specific gravity		7.8706
Hardness		12.715
Elastic limit	pounds	14,000
Extension per inch at rupture	inch	.1623
Ultimate resistance per square inch of original area	pounds	58,000
Reduction in diameter at point of rupture	inch	.14
Original area of cross-section	square inch	.3359
Area after rupture	do	.25[illegible]
Ultimate resistance per square inch of fractured area	pounds	
Position of rupture		near center
Character of surface		fibrous and fine crystalline

APPENDIX No. 38.

REPORT ON THE COMPARATIVE TRIALS OF THE BUTLER AND ARRICK PROJECTILES.

(9 plates.)

By third indorsement by the Chief of Ordnance on letter No. 2107 of 1881, the Ordnance Board was directed to recommend the kind of projectiles to be procured to fill an order for 2,000 8-inch M. L. projectiles.

The Board, in the fourth indorsement on the same letter, stated that for reasons therein set forth further tests would be required to determine the relative merits of the Butler and Arrick, or Eureka, projectiles, and requested that for this purpose 50 8-inch cored shot, of 180 pounds weight, of each pattern be procured. By the fifth indorsement the acting Chief of Ordnance gave authority to procure the shot above mentioned.

September 1, 1881, Colonel Baylor, for the Ordnance Board, requested the commanding officer, United States ordnance agency, to purchase the projectiles.

These projectiles were procured and sent to Sandy Hook, N. J., October 31, 1881, but owing to other and more important experiments on hand the Board did not commence the experiments until January 6, 1882, and they were completed January 11, 1882. The record of firing inclosed shows the pressures and velocities obtained with each projectile, target records of each at mile and 3,000 yard targets, ranges of both over water at 5° and 10° elevation, and observations of the flights of both as to cleanness of sound.

From an analysis of the record the following facts will be shown:

1. The average pressure and velocity with E. V. J. powder (which was the powder mostly used in the experiments), and the Butler projectile, was 29,666 pounds per square inch and 1,374 feet; while with the Arrick they were 27,833 pounds per square inch, and 1,371 feet respectively. These results are so close that neither projectile shows any decided superiority over the other.

2. Observations were made of the flight of the projectiles, both at the targets and when fired over water, as to the sound made in passing through the air, a clear smooth sound indicating a true rotatory motion of the projectile, and an irregular, interrupted sound indicating an imperfect rotation of the projectile.

It will be observed from the summary that there were over 25 per cent. of the Butler projectiles that had an irregular flight, while only a little over 4 per cent. are credited to the Arrick projectile.

3. In considering the target firing we will first examine the records of those made at a mile's distance. The firings at this target were made on January 7, 9, and 10. On the 7th, after firing 3 shots alternately with each projectile to get the proper elevation, 8 shots were fired in the same manner, giving 5 direct hits with each—the mean horizontal deviation being for the Butler 0° 1'.83, and for the Arrick 0'.36. The gun becoming heated the elevation was too great for the last rounds, and it was so marked in the case of the Arrick that the elevation was made 0° 5' less for the last shot. On the 9th 5 shots were fired with each projectile, giving 5 direct hits for the Butler and 3 for the Arrick.

The elevation used for the Butler was found to be too high for the Arrick, the first shot going over the target, and hence the elevation was decreased 0° 10', but this again was too low, as the second shot at this elevation went under the target. On the 10th 5 shots were fired with each projectile; 3 direct hits were obtained with the Butler and 2 with the Arrick. The first shot of this series with the Butler was fired with an elevation of 3° 10', but fell short; the next with an elevation of 3° 15' struck the target, while the third shot with the same elevation fell short; but an elevation of 3° 18' caused both the fourth and fifth shots to strike. The first and second shots with the Arrick were fired under 3° 5' and 3° 10' elevation, respectively, but both fell short. With an elevation of 3° 13' the third and fourth shots gave direct hits, while the fifth under the same angle fell short. The mean horizontal deviations were for the Butler 1'.74, for the Arrick 1'.00.

It thus appears that at this range a less elevation is required for the Arrick projectile, and the horizontal deviation is less. This powder was different from that first used, and the elevations were higher than they would have been with E. V. J.

On the 9th firing commenced at the 3,000-yard range, 3 shots of each kind being fired to determine the elevation, which was found to be 5° 50' for the Butler and 5° 44' for the Arrick. Four shots were then fired with each projectile, and 4 direct hits were obtained with the Arrick, while 3 resulted with the Butler, one shot (the third of the series) falling short. The horizontal deviation was for the Butler 1'.89 and for the Arrick 4'.08. At this range, also, then, the elevation was less for the Arrick, but the horizontal deviation was greater.

On January 11 firing took place over the sea. Five rounds were fired with each projectile under 5° elevation. Two Butler and one Arrick were not located. The mean range for the Butler projectiles was 2,641 yards, the mean lateral deviation 4.44 yards; for the Arrick the mean range was 2,680 yards, and deviation 2.38 yards.

The elevation was then changed to 10°, and 5 rounds of each again fired with the following result: Butler projectile, mean range 4,552 yards, mean lateral deviation 2.24 yards; Arrick projectile, mean range 4,828 yards, mean lateral deviation 2.4 yards.

Consideration of these data shows that on the whole the horizontal and lateral deviations of the two projectiles do not materially differ, although at short ranges they are in favor of the Arrick projectile. For a given range the angle of elevation is decidedly less for the Arrick than for the Butler, and therefore presumably the trajectory is flatter and the dangerous space greater for the Arrick.

4. The cost of the Arrick cored shot is put by the Ames Manufacturing Company at 8 cents per pound, while 9 cents per pound is asked by the South Boston Iron Company for the Butler projectile. The mean

weights would probably average 180 pounds for each, and the cost for 2,000, taking the cored shot as a basis, would be—

2,000 Butler 180-pound shot, at 9 cents per pound	$32,400 00
2,000 Arrick 180-pound shot, at 8 cents per pound	28,800 00
	3,600 00

The Board, from a consideration of the general results of the firings and the difference in the cost of the two projectiles, recommends the procurement of the Arrick projectiles to fill the order for 2,000 8-inch M. L. projectiles.

Target record of firing with 8-inch muzzle-loading

	Number of fire.	Time.	Powder. Kind.	Powder. Weight.	Projectile. Kind.	Projectile. Weight.	Elevation.	Pressure, pounds per square inch of bore.	Instrumental velocity 100 feet from muzzle.	Recoil.	Direction of wind as regards line of fire.
		1882.		*Lbs*		*Lbs*	° '		*Feet.*	*Feet*	
Barometer, 30.336; thermometer, 42; humidity, 92; wind, 13 miles an hour.	88	Jan. 6	Du Pont's hexagonal, E. V. J. Density, 1.750; granulation, 72.	35	Butler ..	180	30	29,000	1,368	2.75	From rear and right.
	89	Jan. 6		35	Arrick ..	180	30	29,500	1,390	3.50	
	90	Jan. 6		35	Butler ..	180	30	32,500	1,388	3.92	
	91	Jan. 6		35	Arrick ..	180	30	25,500	1,357	3.92	
Barometer, 30.225; thermometer, 42; humidity, 92; wind, 10 miles an hour.	92	Jan. 6		35	Butler ..	180	30	27,500	1,367	4.00	From right and front.
	93	Jan. 6		35	Arrick ..	180	30	28,500	1,368	4.17	
A. M.—Barometer, 30.17; thermometer, 38; humidity, 82; wind, 18 miles an hour.	94	Jan. 7		35	Butler ..	180	2 45	......	......	3.50	
	95	Jan. 7		35	Arrick ..	180	2 45	......	......	3.50	
	96	Jan. 7		35	Butler ..	180	2 50	......	......	3.50	
	97	Jan. 7		35	Arrick ..	180	2 50	......	......	3.50	
	98	Jan. 7		35	Butler ..	180	2 55	......	......	3.17	
	99	Jan. 7		35	Arrick ..	180	2 55	......	......	3.00	
P. M.—Barometer, 30.183; thermometer, 39.5; humidity, 82; wind, 13 miles an hour.	100	Jan. 7		35	Butler ..	180	3 05	......	......	2.92	From rear and right.
	102	Jan. 7		35	...do	180	3 05	......	......	2.83	
	104	Jan. 7		35	...do	181	3 05	......	......	2.83	From rear and left.
	106	Jan. 7		35	...do	181	3 05	......	......	2.75	
	108	Jan. 7		35	...do	181	3 05	......	......	2.75	
	110	Jan. 7		35	...do	181	3 05	......	......	2.75	
	112	Jan. 7		35	...do	181	3 05	......	......	2.92	
	114	Jan. 7		35	...do	181	3 05	......	......	2.66	

rifle No. 7, B. I., at Sandy Hook, N. J.

Distance from center of target, in feet.				Distance from center of impact, in feet.				Special remarks about each fire, such as effect on piece, sound of projectile in flight, scattering of fragments, &c.
Vertical.		Horizontal.		Vertical.		Horizontal.		
Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.	
Fired into sand butt for pressures and velocities								Front left guide bolt broken.
Fired at mile target. Sighting shots for elevation								Struck 69 yards in front of target. Struck 17 yards in front of target. Direct hit 9' below 7' left. Under target. Struck 69 yards in front of target. Struck 33 yards in front of target.
Struck ground 8 yards to left and 37 yards beyond target								Flight irregular.
3.50	....	3.50	....	2.32	....	....	1.14	
Struck ground 16 yards in front of target								Flight irregular.
....	2.00	1.20	....	....	3.18	....	3.44	Fired at mile target. Target No. 1 20' × 40', 1-inch spruce.
....	.35	6.00	....	....	1.53	1.36	....	Flight irregular.
6.50	....	6.50	....	5.32	....	1.86	....	
....	1.75	6.00	....	....	2.93	1.36	....	
Over target....		....	....	....	....	....	....	
10.00	4.10	23.20	....	7.64	7.64	4.58	4.58	Mean vertical deviation from center of impact, 3'.06. Mean horizontal deviation from center of impact, 1'.83. Mean deviation from center of impact, 3'.57.
5.90 + 5=1.18		23.20 + 5=4.64		15.28 + 5=3.06		9.16 + 5=1.83		

Target record of firing with 8-inch muzzle

	Number of fire.	Time.	Powder. Kind.	Powder. Weight.	Projectile. Kind.	Projectile. Weight.	Elevation in degrees.	Pressure, pounds, per square inch of bore.	Instrumental velocity, 109 feet from muzzle.	Recoil.	Direction of wind as regards line of fire.
		1882.		*Lbs*		*Lbs*	° ′		*Feet.*	*Feet.*	
A. M.—Barometer, 30.17; thermometer, 38; humidity, 82 per cent.; wind, 18 miles an hour.	101	Jan. 7	Du Pont's hexagonal, E. V. J. Density, 1.750; granulation, 72.	35	Arrick..	180	3 05	......	......	2.83	From right and rear.
	103	Jan. 7		35	...do	180	3 05	......	......	2.75	
	105	Jan. 7		35	..do ...	180	3 05	......	......	2.75	
P. M.—Barometer, 30.183; thermometer, 39.5; humidity, 82 per cent.; wind, 13 miles an hour.	107	Jan. 7		35	.. do	180	3 05	......	......	2.92	From rear and left.
	109	Jan. 7		35	...do	180	3 05	......	......	2.83	
	111	Jan. 7		35	...do	180	3 05	......	......	2.83	
	113	Jan. 7		35	...do	180	3 05	......	......	3.00	
	115	Jan. 7		35	...do	180	3 00	......	......	2.83	
Barometer, 29.91; thermometer, 45; humidity, 89 per cent.; wind, 16 miles an hour.	116	Jan. 9		35	Butler ..	181	3 05	......	......	3.75	From rear and right.
	118	Jan. 9		35	...do	181	3 05	......	......	3.83	
	120	Jan. 9		35	...do	181	3 05	......	......	3.08	
	122	Jan. 9		35	...do	181	3 05	......	......	3.00	
	124	Jan. 9		35	...do	181	3 05	......	......	3.00	
	117	Jan. 9		35	Arrick..	180	3 05	......	......	4.00	
	119	Jan. 9		35	...do	180	2 55	......	......	3.42	
	121	Jan. 9		35	...do	180	2 55	......	......	3.00	
	123	Jan. 9		35	...do	180	3 00	......	......	3.00	
	125	Jan. 9		35	...do	180	3 00	......	......	2.92	

loading rifle No. 7, B. I., &c.—Continued.

Distance from center of target, in feet.				Distance from center of impact, in feet.				Special remarks about each fire, such as effect on piece, sound of projectile in flight, scattering of fragments, &c.
Vertical.		Horizontal.		Vertical.		Horizontal.		
Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.	
	0.65	2.00			4.67		.45	Fired at mile target. Target No. 2, 20′ × 40′, 1-inch spruce.
9.75		2.50		5.73		.05		
7.00		3.00		2.98		.55		
7.00		2.00		2.98			.45	
	3.00	2.75			7.02	.30		
Over target								
Over target								
Over target								
23.75	3.65	12.25		11.69	11.69	.90	.90	Mean vertical deviation from center of impact, 4′.68. Mean horizontal deviation from center of impact, 0′.36. Mean deviation from center of impact, 4′.69.
20.10÷5=4.02		12.25÷5=2.45		23.38÷5=4.68		1.80÷5=0.36		
1.50			.66	2.12			0.13	Fired at mile target. Target No. 3, 20′ × 40′, 1-inch spruce.
4.75				5.37		.53		
	3.00		2.00		2.38		1.47	
	5.25	4.84			4.73	5.37		
	1.00		4.83		.38		4.30	
6.25	9.35	4.84	7.49	7.49	7.49	5.90	5.90	Mean vertical deviation from center of impact, 3′.00. Mean horizontal deviation from center of impact, 2′.36. Mean deviation from center of impact, 3′.82.
3.10÷5= .62		2.65÷5= .53		14.98÷5=3.00		11.80÷5=2.36		
Over target, in line of vertical.								Fired at mile target. Target No. 4, 20′ × 40′, 1-inch spruce.
	7.00		4.00		4.83		2.61	
Under target.								
	2.26	.50			.09	1.89		
2.75			.67	4.92		.72		
2.75	9.26	.50	4.67	4.92	4.92	2.61	2.61	Mean vertical deviation from center of impact, 3′.28. Mean horizontal deviation from center of impact, 1′.74. Mean deviation from center of impact, 3′.71.
6.51÷3=2.17		4.17÷3=1.39		9.84÷3=3.28		5.22÷3=1.74		

Target record of firing with 8-inch muzzle-

	Number of fire.	Time.	Powder. Kind.	Powder. Weight.	Projectile. Kind.	Projectile. Weight.	Elevation.	Pressure, per square inch of bore.	Instrumental velocity, 109 feet from muzzle.	Recoil.	Direction of wind as regards line of fire.
		1882.		*Lbs*		*Lbs*	° ′	*Lbs.*	*Feet.*	*Feet.*	
Barometer, 29.987; thermometer, 46; humidity, 61 per cent.; wind, 23 miles an hour.	126	Jan. 9	Du Pont's hexagonal, E. V. J. Density, 1.750; granulation, 72.	35	Butler ..	181	5 35	......	......	3.08	From rear and right.
	127	Jan. 9		35	Arrick .	180	5 35	......	......	3.08	
	128	Jan. 9		35	Butler ..	181	5 45	......	......	3.00	
	129	Jan. 9		35	Arrick .	180	5 45	......	......	3.00	
	130	Jan. 9		35	Butler ..	181	5 50	......	......	3.00	
	131	Jan. 9		35	Arrick .	180	5 40	......	......	3.00	
	132	Jan. 9		35	...do	180	5 44	......	......	3.00	
	135	Jan. 9		35	...do	180	5 44	......	......	3.17	
	137	Jan. 9		35	...do ...	180	5 44	......	......	3.25	
	139	Jan. 9		35	...do	180	5 44	......	......	3.17	
	133	Jan. 9		35	Butler ..	181	5 50	......	......	3.00	
	134	Jan 9		35	...do	181	5 50	......	......	3.17	
	136	Jan. 9		35	...do	181	5 50	......	......	3.08	
	138	Jan. 9		35	.. do	181	5 50	......	......	3.08	

PLATE 1.

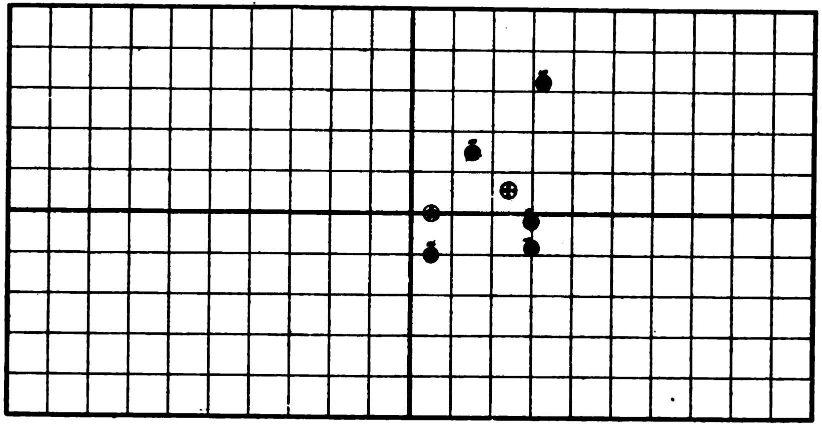
Butler shot

TARGET RECORD of 8 inch M. L. Rifle No. 7, B. S.

AT SANDY HOOK, N. J. January 7. 1882.

Target One Mile from Gun.

Number of shots fired, 8 *Direct hits,* 5 *Ricochet hits,* 1 *Misses,* 2



● *Centre of Impact.*

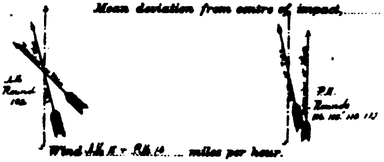
⊕ *Point aimed at.*

Mean vertical deviation from centre of impact, 3.06'

Mean horizontal deviation from centre of impact, 1.83'

Mean deviation from centre of impact, 3.57'

Target 90'x 40'
Made of 1in Spruce board.



Wind A.M. 8. & P.M. 10 *miles per hour.*

Appendix 20—1882.

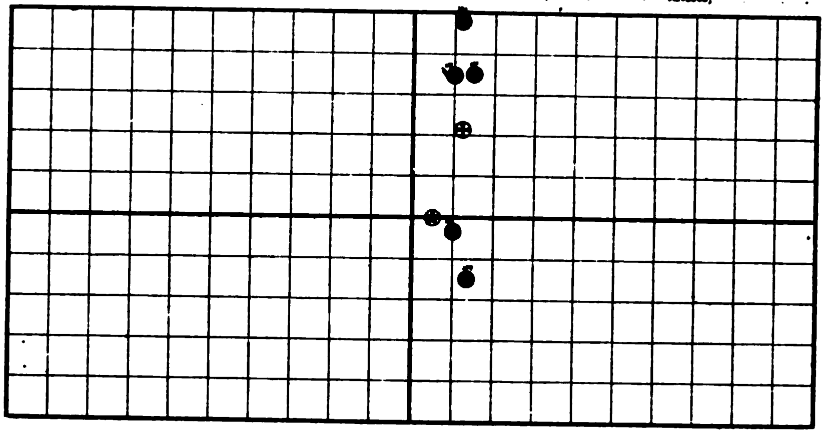
Arrested shot.

TARGET RECORD of Trial M. L. Rifle No 7 B. I

AT SANDY HOOK, N. J. January 7/1882

Target One Mile from Gun.

Number of shots fired, 8 . *Direct hits,* 5 . *Ricochet hits,* 0 . *Misses,* 3 . .



● *Centre of Impact.*

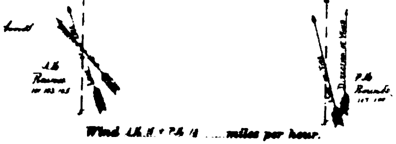
⊕ *Point aimed at.*

Mean vertical deviation from centre of impact, 4.68′

Mean horizontal deviation from centre of impact, .36

Mean deviation from centre of impact, 4.69′

Target 20′ x 40′
Made of 1 in Spruce board



Wind L.B. 11 + P.B. 12 . . . . *miles per hour.*

PLATE III.

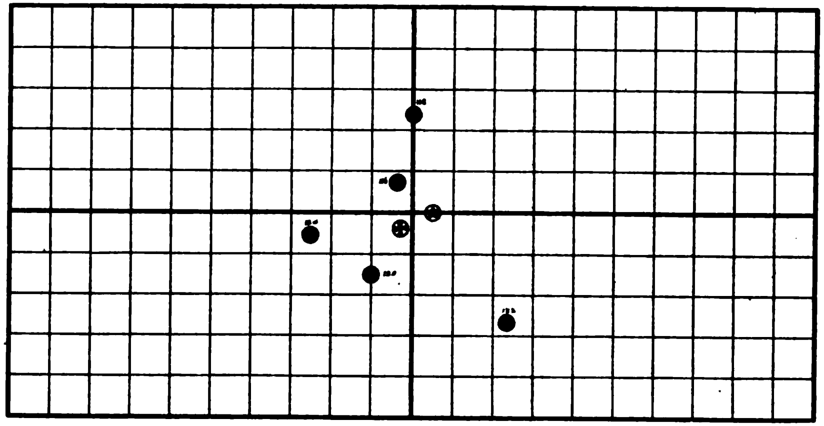
TARGET RECORD of [illegible]

Butler shot

AT SANDY HOOK, N. J. January 9/1882

Target One mile *from Gun.*

Number of shots fired, 5 *Direct hits,* 5 *Ricochet hits,* 0 *Misses,* 0



● *Centre of Impact.*

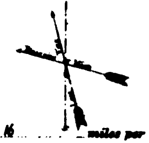
⊕ *Point aimed at.*

Target 80' × 40'
[illegible]

Mean vertical deviation from centre of impact, 3.00'

Mean horizontal deviation from centre of impact, 2.36'

Mean deviation from centre of impact, 3.82'



Wind 16 *miles per hour.*

Appendix 36—1882.

PLATE IV.

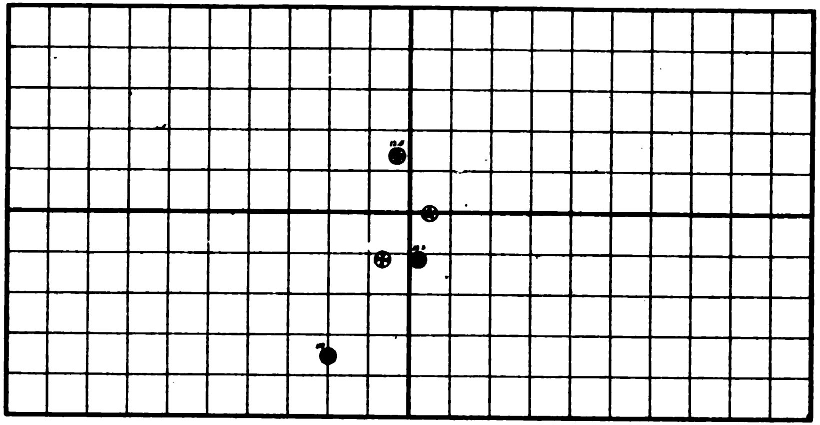
Quick shot.

TARGET RECORD of Swed. M.L. Rifle conv. B.L.

AT SANDY HOOK, N. J. January 9/1882

Target One Mile from Gun.

Number of shots fired. 5 *Direct hits,* 3 *Ricochet hits,* 0 *Misses,* 2



● *Centre of Impact.*

⊕ *Point aimed at.*

Target 20' × 40'
[illegible]

Mean vertical deviation from centre of impact, 3.28'
Mean horizontal deviation from centre of impact, 1.74'
Mean deviation from centre of impact, 3.71'

Wind 15 *miles per hour.*

Appendix 28—1882.

PLATE V.

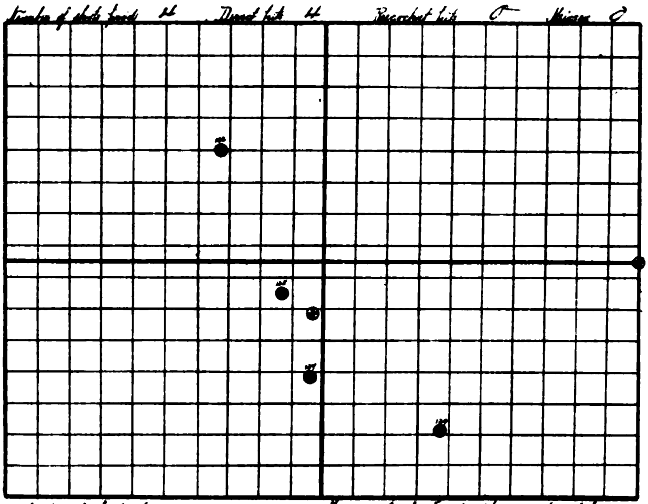
Target Record of 8 inch M. L. Rifle No 7 B.

Quick shot

At Sandy Hook N.J. January 9/1882

Target 3000 yards from Gun

Number of shots fired 4 Direct hits 4 Ricochet hits 0 Misses 0



● Centre of Impact.

⊕ Point aimed at

Target 30' x 40' Made of 1 in spruce board

Mean vertical deviation from centre of Impact 3.77'

" horizontal " " " " 4.08'

" " " " " " 7.07'

Wind 23 miles an hour

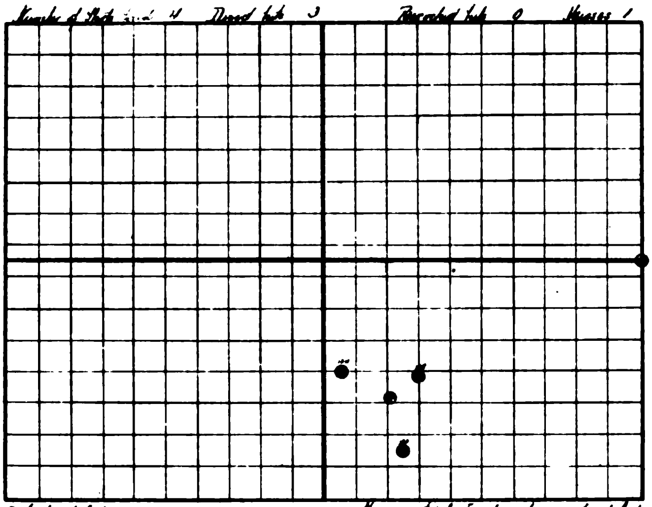
"Target Record of 8 inch M. L. Rifle No 7 B 1

At Sandy Hook N J January 9 1882

Target 3000 yards from Gun.

Butler shot.

Number of Shots fired 4 Direct hits 3 Ricochet hits 0 Misses 1



● Centre of Impact

● Point aimed at.

Target 30' x 40' Made of 1 in spruce boards.

Mean vertical deviation from centre of Impact 2.15'
horizontal . . . . .59'
. . . . 2.86'

Wind 23 miles an hour

PLATE VII.

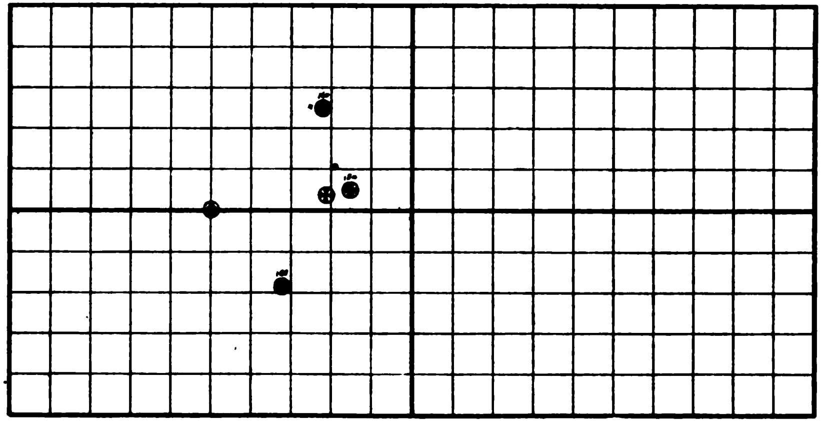
TARGET RECORD of [illegible] Rifle, [illegible]

Butler shot

AT SANDY HOOK, N. J. January 10/1862

Target One mile from Gun.

Number of shots fired, 5 . Direct hits, 3 . Ricochet hits, 1 . Misses, 1 .

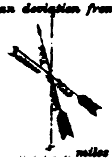


● Centre of Impact.

⊕ Point aimed at.

Target 20' x 40'
Made of [illegible]

Mean vertical deviation from centre of impact, 3.04'
Mean horizontal deviation from centre of impact, 1.74'
Mean deviation from centre of impact, 3.50'



Wind 2 miles per hour.

Appendix 28—1862.

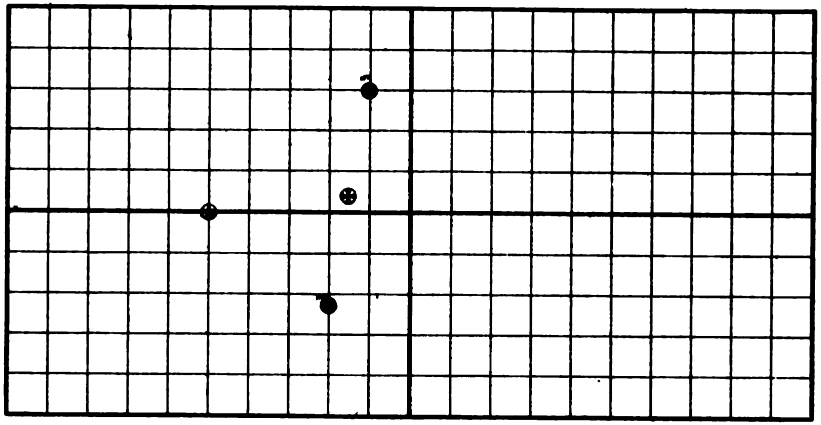
TARGET RECORD of Seml M. L. Rifle Proof B. S.

Quick shot

AT SANDY HOOK, N. J. January 10/1882.

Target One Mile from Gun.

Number of shots fired, 5 . Direct hits, 2 . Ricochet hits, 3 . Misses, 0



● Centre of Impact.

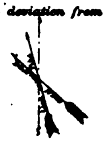
⊛ Point aimed at.

Mean vertical deviation from centre of impact, 5.25

Mean horizontal deviation from centre of impact, 1.60.

Mean deviation from centre of impact, 5.34

Target 20' x 40', Made of 1' Square Boards



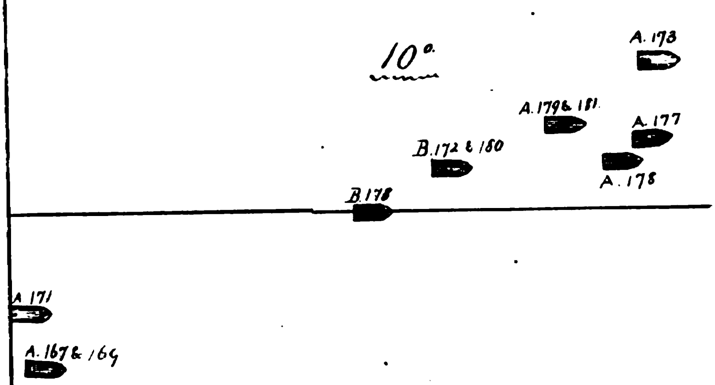
Wind 2 miles per hour

PLATE IX.

fle No. 7. B.

882

Airrick & Bu.



Appendix 38—1882.

loading rifle No. 7, B. I., &c.—Continued.

	Distance from center of target, in feet.				Distance from center of impact, in feet.				Special remarks about each fire, such as effect on piece, sound of projectile in flight, scattering of fragments, &c.
	Vertical.		Horizontal.		Vertical.		Horizontal.		
	Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.	
Fired at 3,000 yard target.	Struck 100 yards in front of target								
	Under target, 10 feet to left of vertical								
	Under target, in line of vertical								
	Over target, about line of vertical								
	Direct hit; 15′ right, 11′ below								Flight irregular.
	Under target, line 2 feet to right of vertical								
	7.00	....	....	6.83	10.27	....	....	6.17	Fired at 3,000 yard target. Target No. 5, 30′ × 40′, 1-inch spruce.
	....	2.00	....	2.56	1.27	....	....	1.90	
	....	7.33	....	.75	....	4.06	....	.09	
	....	10.75	7.50	....	....	7.48	8.16	....	
	7.00	20.08	7.50	10.14	11.54	11.54	8.16	8.16	Mean vertical deviation from center of impact, 5′.77. Mean horizontal deviation from center of impact, 4′.08. Mean deviation from center of impact, 7′.07.
	13.08+4=3.27		2.64+4=.66		23.08+4=5.77		16.32+4=4.08		
	....	12.00	5.00	....	....	3.22	.92	....	Fired at 3,000 yard target. Target No. 6, 30′ × 40′, 1-inch spruce.
	....	7.00	1.24	....	1.78	....	....	2.84	
	Struck 300 yards in front of target								
	....	7.34	6.00	....	1.44	....	1.92	....	
	....	26.34	12.24	....	3.22	3.22	2.84	2.84	Mean vertical deviation from center of impact, 2′.15. Mean horizontal deviation from center of impact, 1′.89. Mean deviation from center of impact, 2′.86.
	26.34+3=8.78		12.24+3=4.08		6.44+3=2.15		5.68+3=1.89		

Target record of firing with 8-inch muzzle-

	Number of fire.	Time.	Powder.		Projectile.		Elevation.	Pressure, per square inch of bore.	Instrumental velocity, 100 feet from muzzle.	Recoil.	Direction of wind as regards line of fire.
			Kind.	Weight.	Kind.	Weight.					
		1882.		*Lbs*		*Lbs*	° ′	*Lbs.*	*Feet.*	*Ft.*	
Barometer, 30.411; thermometer, 37.8; humidity, 53; wind, 12 miles an hour.	140	Jan. 10	Du Pont's hexagonal, E. V. J. Density, 1,720; granulation, 72.	35	Butler ..	181	5 50	......	......	3.42	From rear and right.
	141	Jan. 10		35	Arrick .	180	5 44	......	......	3.33	
	142	Jan. 10		35	Butler ..	181	5 55	......	......	3.17	
	143	Jan. 10		35	Arrick .	180	5 50	......	......	3.00	
	144	Jan. 10		35	Butler ..	181	6 00	......	......	3.33	
	145	Jan 10		35	Arrick .	180	5 54	......	......	3.17	
	146	Jan. 10	Du Pont's hexagonal, I. O. A. Density, 1.785; granulation, 67.	35	Butler ..	181	5 40	......	......	3.00	
	147	Jan. 10		35	Arrick .	180	5 40	......	......	3.00	
	148	Jan. 10		35	Butler ..	181	40	......	1,294	3.17	
	149	Jan. 10		35	Arrick .	180	30	......	1,285½	3.06	
	150	Jan. 10	Du Pont's hexagonal, E. V. N. Density, 1.750; granulation, 72.	35	Butler ..	181	30	21,500	1,324	3.42	
	151	Jan. 10		35	Arrick .	180	15	24,500	1,336	3.42	
Barometer, 30.350; thermometer, 35; humidity, 89; wind, 2 miles an hour.	152	Jan. 10		35	Butler ..	180	3.10	......	......	3.42	
	154	Jan. 10		35	...do	180	3.15	......	......	3.33	
	156	Jan. 10		35	...do	182	3.15	......	......	3.33	
	158	Jan. 10		35	...do	182	3.18	......	......	3.33	
	160	Jan. 10		35	...do	182	3.18	......	......	3.33	
	153	Jan. 10		35	Arrick .	180	3.05	......	......	3.25	
	155	Jan. 10		35	...do	180	3.10	......	......	3.33	
	157	Jan. 10		35	...do	180	3.13	......	......	3.33	
	159	Jan. 10		35	...do	180	3.13	......	......	3.33	
	161	Jan. 10		35	...do	180	3.13	......	......	3.33	

loading rifle No. 7, B. I. &c.—Continued.

Distance from center of target, in feet.				Distance from center of impact, in feet.				Special remarks about each fire, such as effect on piece, sound of projectile in flight, scattering of fragments, &c.
Vertical.		Horizontal.		Vertical.		Horizontal.		
Above.	Below.	Right.	Left.	Above.	Below.	Right.	Left.	
Fired at 3,000 yards target. Struck 100 yards in front of target.								
Struck 35 yards in front of target.								
Struck 45 yards in front of target.								
Struck 400 yards in front of target.								
Struck 40 yards in front of target								Flight irregular.
Direct hit, 13′ right; 7′ below.								
Struck 350 yards in front of target								Flight slightly irregular.
Struck just beyond mile target. Sabot did not take grooves								Flght very irregular.
Fired into sand butt for velocities.								
Fired into sand butt for pressures and velocities.								
Struck 40 yards in front of target; flight irregular								
1.00	....	....	1.50	.28	....	2.61	....	Flight slightly irregular. Fired at mile target. Target No. 7, 20′×40′, 1 inch spruce.
Struck 20 feet in front of target.								
....	3.84	....	6.33	....	4.56	....	2.22	
5.00	....	....	4.50	4.28	....	....	.39	
6.00	3.84	....	12.33	4.56	4.56	2.61	2.61	Mean vertical deviation from center of impact, 3′.04. Mean horizontal deviation from center of impact, 1′.74. Mean deviation from center of impact, 3′.50.
2.16+3=.72		12.33+3=4.11		9.12+3=3.04		5.22+3=1.74		
Struck 25 feet in front of target.								
Struck 40 feet in front of target.								Fired at mile target. Target No. 8, 20′×40′, 1 inch spruce.
6.00	....	....	2.00	5.25	....	1.00	....	
....	4.50	....	4.00	....	5.25	....	1.00	
Struck 50 feet in front of target; stripped in flight								
6.00	4.50	....	6.00	5.25	5.25	1.00	1.00	Mean vertical deviation from center of impact, 5′.25. Mean horizontal deviation from center of impact, 1′.00. Mean deviation from center of impact, 5′.34.
1.50+2=.75		6.00+2=3.00		10.50÷2=5.25		2.00+2=1.00		

Target record of firing with 8-inch

	Number of fire.	Time.	Powder. Kind.	Powder. Weight.	Projectile. Kind.	Projectile. Weight.	Elevation.
		1882.		*Lbs*		*Lbs.*	
Barometer, 29.948; thermometer, 42; humidity, 74; wind, 24 miles an hour.	162	Jan. 11	Du Pont's hexagonal powders, E. V. L., E. V. M., and G. Q., thoroughly intermixed in following proportion: E. V. L., 5.45 pounds; E. V. M., 13.45 pounds; G. Q., 16.10 pounds. Total 35 pounds. (Density of each, 1.750; granulation, 72).	35	Butler	182	5
	163	Jan. 11		35	Arrick........	180	5
	164	Jan. 11		35	Butler	182	5
	165	Jan. 11		35	Arrick........	180	5
	166	Jan. 11		35	Butler	182	5
	167	Jan. 11		35	Arrick........	180	5
	168	Jan. 11		35	Butler	180	5
	169	Jan. 11		35	Arrick........	180	5
	170	Jan. 11		35	Butler	184	5
	171	Jan. 11		35	Arrick........	180	5
	172	Jan. 11		35	Butler	183	10
	173	Jan. 11		35	Arrick........	180	10
	174	Jan. 11		35	Butler	179	10
	175	Jan. 11		35	Arrick........	180	10
	176	Jan. 11		35	Butler	179	10
	177	Jan. 11		35	Arrick........	180	10
	178	Jan. 11		35	Butler	179	10
	179	Jan. 11		35	Arrick........	180	10
	180	Jan. 11		35	Butler	179	10
	181	Jan. 11		35	Arrick........	179	10

Weight of Arrick sabot, 10 pounds, 5½ ounces.

loading rifle No. 7, B. I., &c.—Continued.

Deflection in yards.	Direction of wind as regards line of fire.	Special remarks about each fire, such as effect on piece, sound of projectile in flight, scattering of fragments, &c.			
	From rear and right.	Fired to sea for ranges.		Lost	Average Butler, 2,641 yards. Average Arrick, 2,680 yards.
				Lost	
				Lost	
19 right				2,565 yards	
18 right				2,620 yards	
15 right				2,720 yards	
18 right			Irregular flight	2,620 yards	
15 right				2,720 yards	
8 right				2,683 yards	
10 right				2,715 yards	
4 left				4,664 yards	Average Butler, 4,552 yards. Average Arrick, 4,828 yards.
15 left				4,864 yards	
None			Irregular flight	4,448 yards	
5 left				4,849 yards	
2 right			Irregular flight	4,406 yards	
7 left			Irregular flight at start	4,857 yards	
None				4,577 yards	
9 left				4,785 yards	
4 left				4,664 yards	
left				4,785 yards	

Weight of Butler sabot, 9 pounds, 15¼ ounces.

APPENDIX 39.

REPORT ON PROTECTION OF GUNPOWDER MAGAZINES FROM LIGHTNING.

(3 plates.)

PICCATINNY POWDER DEPOT,
Dover, N. J., February 1, 1882.

SIR: I am gravely impressed with the importance of a proper selection and correct arrangement of conductors to insure to the large magazine buildings at this post as complete protection from lightning as possible, and I have given some attention to the subject. The questions as to the kind, number, and size of conductors, the mode of attaching them to the building, the character of earth terminations, &c., &c., now demand an answer at least with reference to the magazine already built.

There seems to be a difference of opinion among authorities, and there are also some peculiarities in the construction of this magazine, notably the metal roof, which might affect the decision, and which I have not seen in any case where the best methods for protection from lightning has been discussed.

I therefore request instructions on the above-mentioned subjects, or that I may have the benefit of the opinion and judgment of a board of officers, either the Ordnance Board or a special board, to aid in a correct determination on these doubtful points.

Very respectfully, your obedient servant,
F. H. PARKER,
Major of Ordnance, Commanding.

CHIEF OF ORDNANCE, U. S. A.,
Washington, D. C.

THE ORDNANCE BOARD, U. S. A.,
NEW YORK ARSENAL,
Governor's Island, New York Harbor, March 29, 1882.

Proceedings of the Ordnance Board under the provisions of the following order:

[Special Orders No. 29—Extract.]

HEADQUARTERS OF THE ARMY,
ADJUTANT-GENERAL'S OFFICE,
Washington, February 6, 1882.

* * * * * * *

5. By direction of the Secretary of War, the Ordnance Board, consisting of—
Lieutenant-Colonel Thomas G. Baylor,
Major George W. McKee,
Captain Charles Shaler,
will proceed to the Piccatinny powder depot, New Jersey, to determine on the best method of protecting the gunpowder magazines from the effects of lightning.

They will report their opinions and recommendations to the Chief of Ordnance.

* * * * * * *

By command of General Sherman.

R. C. DRUM,
Adjutant-General.

Official.

H. C. CORBIN,
Assistant Adjutant-General.

In accordance with the foregoing order the Board, on February 9, 1882, proceeded to Dover, N. J., to consult with the commanding officer of the Piccatinny powder depot, to examine his plans for protecting the magazine against lightning, and to observe the location and arrangement of the buildings.

The plans submitted are inclosed herewith.

The magazine tract lies in a valley surrounded by high rocky hills. The nature of the hills is such that the well-watered valley would probably afford a better conducting surface than the higher ground. The magazine is covered with a roof of corrugated iron, supported by roof trusses. The outside doors and shutters are of wrought-iron plate. Taking into consideration the construction of the building and the nature of the surface upon which it stands, it would probably afford the medium through which discharge if it take place in the vicinity would occur.

The points presented for consideration will now be taken up in detail

MATERIAL FOR CONDUCTORS.

In general the weight of authority indicates that copper should be used on account of its high conducting power and its resistance to rapid deterioration from oxidation or the action of deleterious gases.

In this particular case, however, its use would be objectionable, for the reason that its contact with the roof, whether direct or through the medium of holdfasts, which should be of the same material as the conductor, would be liable to set up galvanic action, and thereby cause injury to the roof, or to the conducting power of the holdfasts or to both.

Iron should therefore be used, and its inferior conductivity may be compensated for by increased cross-section; and thereby an additional advantage is gained, namely, that a larger mass of a material having a much higher fusing point than that of copper is presented for the passage of the current. By galvanizing and painting the iron its oxidation can be prevented for a long time.

TERMINALS.

The terminals should be galvanized wrought-iron rods, each having a beveled and gilded extremity, surrounded by a collar of wrought iron screwed and soldered to the rod a little below its upper end. This collar should be provided with pointed iron wires gilded like the extremity and for the same reason, viz, to prevent destruction by rust. The fine points would facilitate silent discharge, while disruptive discharge could take place through the beveled extremity without danger of fusion.

CONDUCTORS AND CONNECTORS.

By using galvanized iron wire rope for the greater part of the system very few joints will be required. The rope, as indicated in figure on Plate I, passes through a wrought-iron T. The galvanized rod will rest in the vertical part of the T, and when the whole connection is well soldered, it will make a joint of a conducting power equal to that of the wire rope. At the ridge of the roof is a plate almost circular in section, called the "ridge roll." This permits the use of a convenient connector for the rope which is shown in figure on Plate I. The surface of contact has such an extent that it exceeds six times the cross-section of the rod, and thus complies with the requirement that the surface at a joint should be at least six times the sectional area of the conductor. The rope may lie upon the roof itself, but where it passes over the eaves it should be curved, so that the length of the curved part may not be such as to admit of disruptive discharge between the straight parts.

The holdfasts should be of iron, and should allow the rope to expand and contract freely. It is feasible to secure moist contact for the deep earths in this locality, and by allowing each continuous rope, as indicated, to run down on either side of the building, and to terminate at a plate always moist, it would seem that every benefit obtainable would be secured. A horizontal wire rope should connect all the vertical ropes, so that should one of the latter be injured all the rest of the system acts to aid it. The metal shutters and doors should be connected to the general system by galvanized iron straps equal in cross-section to the conductors themselves. The girders and columns should not be connected either with the earth or external system of conductors.

EARTHS.

Advantage should be taken of the down spouts (three on each side) to lead the central and extreme conductors through them, permitting them to pass under the surface drains, so that a moist surface earth would be obtained almost immediately after the commencement of rain. With a view to increasing the extent of this contact the ropes should be carried under ground for some distance from the building, as shown in Plate III, before passing downward to the deep earth. The deep earth itself should be a cast-iron water-pipe, to which the ends of the wire ropes are securely soldered. It should be about ten feet long, and a foot in diameter, thus giving an exterior surface of thirty feet, which is considered ample. It should be placed in a well always moist, a condition which, as stated before, may be readily secured in this place.

TESTING.

While some simple method of testing for loss of conductivity or breaks in the circuit would be desirable, the continuity of the proposed system render it impracticable, and at the same time diminishes its importance.

SIZE OF CONDUCTORS.

An examination of the best authorities on the subject and a consideration of all the circumstances indicate that a galvanized iron wire rope one inch in diameter for the main conductors, a galvanized rod of one inch round iron, and such dimensions as are suitable for the straps connecting the shutters and doors as will give them a cross-section of about seven-tenths of an inch, will be the best arrangement.

HEIGHT OF TERMINALS.

Much diversity of opinion exists on this subject, so that it is believed such a height as will permit a convenient examination of the points will be suitable.

NUMBER.

The building is 200 feet long, and it is considered that 5 rods should be erected giving a distance of 50 feet between each.

SUMMARY.

The Board would recommend that the magazine examined should be provided with five conductors of one-inch galvanized iron wire rope, well painted, each conductor to run continuously from the ridge down opposite faces of the building, and to be connected by a soldered joint with a cast-iron water-pipe 10 feet long, one foot in diameter, inserted in a wet well; the central and extreme conductors to pass through the water-spouts. The curvature at the eaves to be such that the length of the curved portion shall not exceed one and one-half times the distance between the initial and terminal points of the curve.

That the upper terminal of each conductor should be a one-inch galvanized iron rod with a beveled and gilded extremity, surrounded at one foot from the end by an iron collar screwed and soldered to it, holding six equi-distant pointed and gilded iron wires six inches long. The length of the terminal rods should not exceed six feet.

That the vertical portions of the wire rope should be connected by a horizontal rope of the same kind and size, above ground.

That the holdfasts should be of iron and allow free movement to the rope in expansion and contraction.

That the door and shutter connections and the surface and deep earth be arranged as previously described.

In everything relating to this matter the Board has freely consulted with the commanding officer of the powder depot, and his views are in full accordance with those herein expressed.

For information on this subject recourse has been had to the paper of Captain J. T. Bucknill, Royal Engineers, published in Ordnance Notes No. 168, to the report of the "Lightning-rod conference," published in 1882, and to various other authorities.

ROOF CONNECTION.

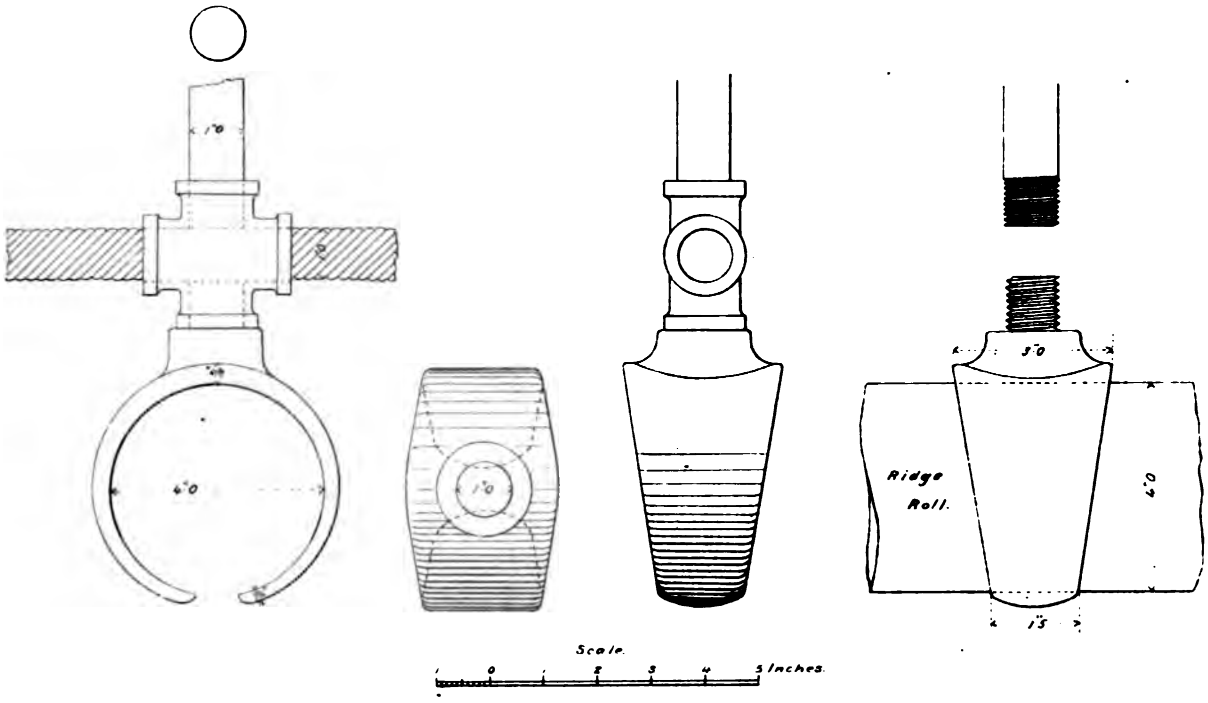
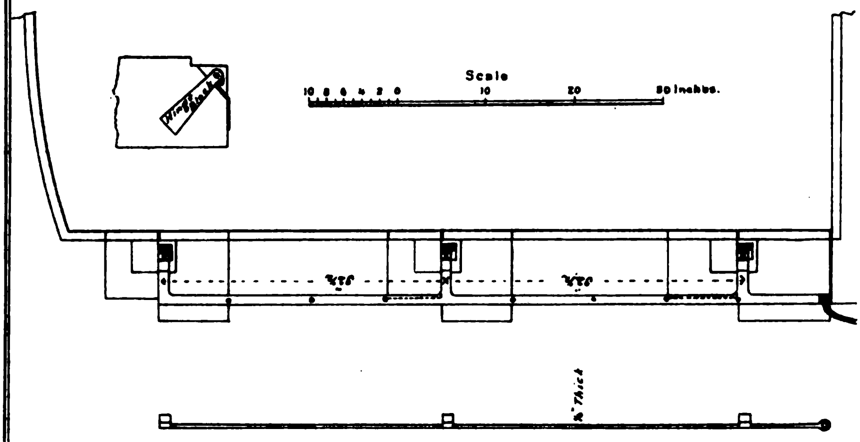
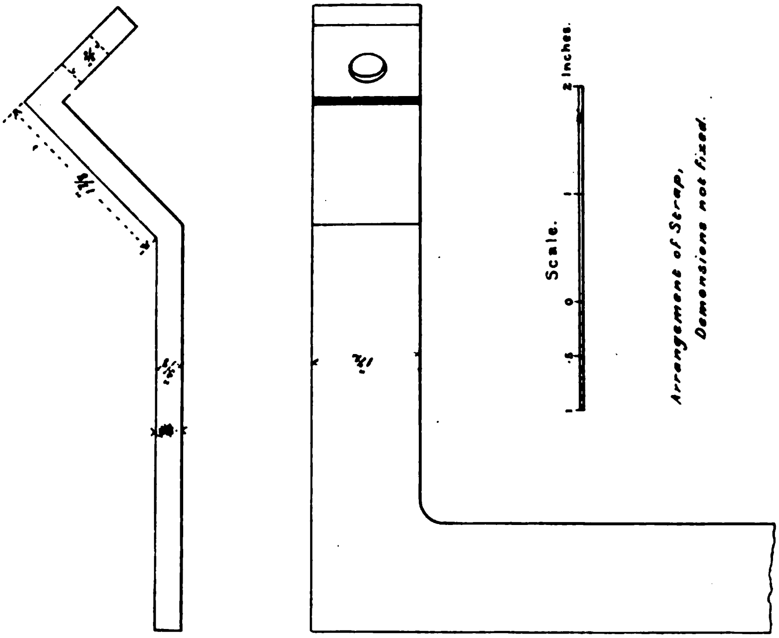


PLATE II.

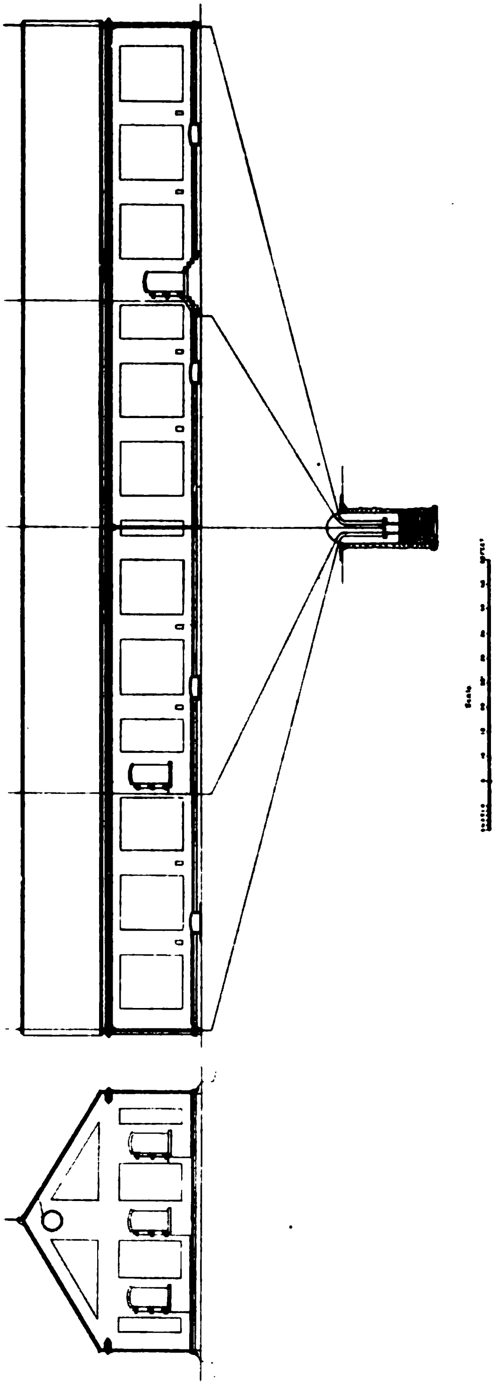




Arrangement of Strap,
Demensions not fixed.

PLATE III

MAGAZINE
PICCATINNY POWDER DEPOT



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